PB83-251553

Draft Environmental Impact Statement North Carolina Barrier Island Wastewater Management

(U.S.) Environmental Protection Agency
Atlanta, GA

Jun 83

U.S. Department of Commerce
National Technical Information Service
NTIS

BIBLIOGRAPHIC DATA SHEET	**1. Report No.** EPA 904/9-83-108a	**2.**	**3. Recipient's Accession No.** PB83 251553

4. Title and Subtitle
North Carolina Barrier Island Wastewater Management Draft Environmental Impact Statement

5. Report Date
June 1983

6.

7. Author(s)
Environmental Assessment Branch, NEPA Compliance Section

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
U.S. Environmental Assessment Branch
345 Courtland Street
Atlanta, GA 30365

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address
Same as box 9

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstracts

This Draft Environmental Impact Statement (EIS) provides assistance in wastewater management planning for North Carolina's Barrier Island communities. It presents a step-by-step process that can assist facilities planners in resolving the unique problems encountered on North Carolina's Barrier Islands and result in a cost-effective and environmentally sound management system. Once this process has been finalized, communities involved in facilities planning will be encouraged to use the tools developed in this EIS wherever appropriate.

17. Key Words and Document Analysis. 17a. Descriptors

Draft EIS
North Carolina
Barrier Islands

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

18. Availability Statement

1<

19. Security Class (This Report) UNCLASSIFIED	**21. No. of Pages**	
20. Security Class (This Page) UNCLASSIFIED	**22. Price**	

PB83-251553

United States
Environmental Protection
Agency

Region 4
345 Courtland Street, NE
Atlanta, GA 30365

EPA 904/9-83-108a
June 1983

Environmental Impact Statement

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REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

United States
Environmental Protection
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DRAFT
ENVIRONMENTAL IMPACT STATEMENT

NORTH CAROLINA BARRIER ISLANDS
WASTEWATER MANAGEMENT

prepared by
U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV, ATLANTA, GEORGIA 30365

This Draft Environmental Impact Statement (EIS) provides assistance in wastewater management planning for North Carolina's Barrier Island communities. It presents a step-by-step process that can assist facilities planners in resolving the unique problems encountered on North Carolina's Barrier Islands and result in a cost-effective and environmentally sound management system. Once this process has been finalized, communities involved in facilities planning will be encouraged to use the tools developed in this EIS wherever appropriate.

Comments or inquiries should be forwarded to:

E.T. Heinen, Chief
Environmental Assessment Branch
Environmental Protection Agency
345 Courtland Street, N.E.
Atlanta, Georgia 30365
404/881-3776

Approved by:

Charles R. Jeter
Regional Administrator

May 24, 1983
Date

NORTH CAROLINA BARRIER ISLANDS

WASTEWATER MANAGEMENT

ENVIRONMENTAL IMPACT STATEMENT

Draft (X)
Final ( )

Environmental Protection Agency
Region IV
345 Courtland Street
Atlanta, Georgia 30365

Type of Action:	
Administrative Action	(X)
Legislative Action	( )

EXECUTIVE SUMMARY

PART A. INTRODUCTION

This EIS provides assistance to local governments in the completion of planning for wastewater management facilities on the North Carolina barrier islands. It gives facilities planners a step-by-step process for wastewater management planning. This process is intended to assist in resolving the unique problems encountered on North Carolina's barrier islands and to result in a cost-effective and environmentally sound management system. This process is called the EIS Strategy in this Draft EIS.

The EIS Strategy and two other strategies are examined in this EIS. The other two strategies are the 201 Strategy, which is the implementation of existing 201 Plans without revision, and the No Federal Action Strategy, which provides no further federal funding of any wastewater facilities on the North Carolina barrier islands.

After careful evaluation, the EIS Strategy is proposed as the best approach to cost-effective and environmentally sound wastewater management planning for North Carolina's barrier islands. Once this strategy or process has been finalized, communities involved in facilities planning will be encouraged to use the tools developed in this EIS wherever appropriate.

PART B. BACKGROUND

Draft 201 Facilities Plans, which included many of North Carolina's barrier islands, have proposed the construction of wastewater collection, transportation and treatment facilities to serve large portions of these islands. After an environmental review of the proposed facilities, EPA had significant concerns about the potential impacts of these facilities.

The preparation of a facilities plan is the first step in EPA's three step Construction Grants program for wastewater facilities. To be eligible for federal funding, proposed facilities must be part of an approved facilities plan. Steps 2 and 3 of the Construction Grants program are design and construction, respectively.

EPA funding of the proposed facilities was determined to be a major Federal Action significantly affecting the quality of the human environment; thus a decision to prepare an EIS was made. EPA decided that the preparation of an areawide EIS in North Carolina would result in a consistent approach in EPA's decisions on funding of wastewater facilities for the North Carolina barrier islands. Furthermore, EPA determined that an areawide EIS would be the most expeditious way of addressing the issues involved and promoting cost effective, environmentally sound decisions.

The issues that have been addressed by this EIS are:

1. Water Quality - A determination of existing water quality, especially the documentation of water quality problems, is important. The draft 201 Plans attempted to justify the need for facilities on the barrier islands based on the pollution of shellfishing waters by failing septic tanks. Existing data did not support this position. Nonpoint mainland surface runoff sources (not septic tanks) appeared to be the problem. The only exceptions were some documented problems in finger-fill canals on several different islands.

2. Alternative Wastewater Techniques - All available technologies for wastewater management on the barrier islands were not evaluated by the 201 Plans. On-site and small community systems may provide appreciably more cost effective alternatives that could support low, medium and potentially high density development.

3. Financial Impact on Local Governments - The financial impact on small municipal governments of operating and maintaining centralized sewer systems is a major issue. Implementation of the draft 201 Plans by these small governments with a narrow tax base and dependence on the tourist industry may place a financial burden on the community and its wastewater customers or taxpayers. The draft 201 Plans have not demonstrated financial and institutional capability for these communities.

4. Nonpoint Source Pollution - Studies in coastal areas in the Southeast have shown that nonpoint runoff is responsible for closure of shellfishing waters where sewer systems exist. New waste disposal facilities may promote higher density development, thus increasing the potential for nonpoint source pollution of estuarine waters. This potential adverse impact has been addressed in the EIS.

5. Groundwater - The EIS addressed the potential impacts on groundwater hydrology from the application of effluent to the soil. The potential for contamination of shallow groundwater by soil absorption wastewater systems was examined. The quality and quantity of this resource, as well as its current and potential use as a drinking water supply, were considered.

6. Sensitive Natural Areas - The EIS has addressed the primary and secondary impacts of wastewater management facilities on sensitive natural areas such as dunes, wetlands and estuarine waters. The effectiveness of the

N. C. Coastal Area Management Program is an important factor in addressing the impacts on these systems.

PART C. STRATEGY FOR WASTEWATER MANAGEMENT

A strategy for wastewater management on the North Carolina barrier islands was developed through the EIS process. This strategy is intended to provide assistance to local governments in planning for wastewater management for North Carolina barrier islands.

The process of applying the strategy to existing draft 201 Plans or in future planning efforts will consist of investigating the various alternatives available for each 201 area by using procedures developed in the EIS as appropriate. The primary and secondary environmental impacts, as well as the costs, reliability, and implementability of each alternative, will be addressed.

The EIS strategy is that communities involved in facilities planning are encouraged to update and revise their draft 201 Plans as appropriate using procedures developed by the EIS. The EIS procedure focuses on refinements to population and land use analysis, development of wastewater flows, evaluation of alternative wastewater systems, and financial and institutional considerations which are appropriate for barrier islands.

The procedures are consistent with construction grants regulations and other facilities plan preparation guidance; however, they are tailored and refined to address the unique environmental and socioeconomic conditions on the N. C. barrier islands. The procedures were designed to address the six issue areas identified earlier. Special attention was given to two areas which were most lacking in the draft 201 Plans: (1) a thorough evaluation of all wastewater technologies, especially on-site and small community systems, and (2) financial and institutional impacts of operating and maintaining wastewater management systems.

These procedures provide tools to assist the 201 applicant in: (1) determining need and estimating flows, (2) developing viable alternative wastewater management systems, and (3) evaluating alternative wastewater management systems.

These tools are designed to identify all viable alternative systems and to promote consideration of the major potential impacts on both the man-made and natural environments. The use of these procedures and tools will not mean that all 201 planning areas will end up with all on-site and small community systems. The procedures will allow them to be fully considered, however.

A case study analysis was performed on a hypothetical barrier island to assist in identifying alternatives and their impacts under the EIS Strategy. The island was designed to incorporate features common to most 201 study areas so as to broaden the case study's applicability. The cost impacts shown below are taken from the case study.

The EIS has identified the following potential impacts resulting from implementation of the EIS strategy:

1. Costs

   a. The cost of this strategy is low to moderate. (The EIS case study found this alternative to cost approximately $2.6 to 4.2 million.)

   b. Relatively low capital and O&M costs will not be a financial burden on local governments and users.

   c. Additional costs will be realized to update the 201 Plans. These reasonable costs will be 75 percent grant eligible.

2. Implementability

   a. Draft 201 Plans may be revised through use of the EIS. These revisions may be lengthy and costly in some cases.

   b. Existing development will continue to use on-site systems while future development will tend to use a greater proportion of community systems, especially with increased condominium development.

   c. An on-site management agency would not require a highly sophisticated technical support system.

   d. Federal and state funds may be available to resolve existing documented pollution problems.

   e. Septic tanks may surface in storm overwash, making repair necessary for property owners.

3. Reliability

   a. The mechanical reliability of on-site systems and small community systems are high although they are susceptible to some storm damage if erosion or flooding occurs.

   b. The reliability of treatment processes are high if systems are properly installed, operated and maintained.

   c. Reliability of operation on a community-wide basis is high if systems are centrally managed by a public agency.

4. Primary Environmental Impacts

   a. Construction impacts will probably tend to be localized to areas of new development and documented water quality problems.

   b. Functioning on-site and community systems are more likely to be retained.

   c. High density development with soil absorption disposal would raise the groundwater table and would locally raise nitrate levels in groundwater.

d. The potential for pollution incidents due to storm damage may be reduced by using on-site and community systems.

5. Secondary Environmental Impacts

a. The strategy allows future development flexibility and desired development density and locations.

b. Future development will likely contain a mixture of high and low densities in response to community land use values and the need for environmental protection.

c. Lower density development will minimize the volume of stormwater runoff per developed acre, thus having less of an impact on water quality and shellfish harvesting areas.

PART D. ALTERNATIVES TO THE PROPOSED STRATEGY

The EIS compared the proposed strategy to the alternatives of no action (No Federal Action Strategy) and of approving the draft 201 Plans as submitted (201 Strategy). These two alternative strategies and their impacts are described below.

The No Federal Action Strategy

The No Federal Action Strategy would be a decision by EPA not to participate in the further planning or funding of wastewater management facilities in the study area. Analysis of this strategy by the EIS projects continued growth on the barrier islands even if publicly-owned and funded facilities are not constructed. Without additional EPA assistance, existing wastewater management practices will continue. Localized state regulations will govern the use of soil absorption systems. Individual property owners will be responsible for providing adequate treatment and will bear the cost of renovating failing systems or installing new facilities.

The EIS identified the following potential impacts should the No Federal Action Strategy be implemented:

1. Costs

a. This is the lowest cost strategy. (The EIS case study found this alternative to cost approximately $1.4 million).

b. Costs associated with implementing this strategy will primarily be the responsibility of property owners and developers with some assistance possible from the state for specific studies or projects.

2. Implementability

a. The institutional mechanisms for implementing this strategy are currently in place and functioning.

b. Functioning on-site systems would be retained.

c. Storm damage to wastewater systems should be minimal since most systems are underground; however, septic tanks may surface in storm overwash, causing expense to individual property owners.

3. Reliability

a. Mechanical reliability of on-site and small community systems is high when new. Reliability will decrease as the systems age due to sporadic maintenance.

b. Reliability of treatment processes is high initially but will probably decline over time due to sporadic maintenance.

c. Reliability of operation on a community-wide basis is low since no centralized management is likely to be provided.

4. Primary Environmental Impacts

a. Improperly installed and operated on-site systems could cause a localized elevation of nitrate and bacterial concentrations in surface waters. This is occurring in a few isolated finger-fill canal areas.

b. Existing water quality problems in such areas may not be identified and corrected.

c. Construction impacts would be confined to new developments and areas with failing systems requiring new or modified systems.

5. Secondary Environmental Impacts

a. Lower density development minimizes the potential for adverse impacts to surface waters from stormwater runoff.

b. High density developments must give more detailed consideration to wastewater facilities prior to construction.

The 201 Strategy

The 201 Strategy would be the approval and implementation of the draft plans without significant changes. The plans would have to be updated in certain areas such as costs. Those plans proposing ocean outfalls (Dare County and Carteret County) would have to incorporate the results of site-specific surveys. The Carteret County plan for the barrier islands would have to be modified since one of the two communities involved elected not to participate.

One of the six plans, Hatteras Island, proposes no action because it was determined that a system is not economically feasible at this time. The other five plans exhibit several similarities. Each plan calls for the replacement of existing on-site wastewater systems (septic systems) with centralized collection, transmission, treatment, and disposal systems. These plans justified the need for facilities based on reports of shellfishing harvest area closings due to elevated fecal coliform counts. The plans also projected additional shellfish area closings with continued rapid residential and commercial developments using on-site systems.

Another similarity is the proposal to provide sewer lines to all areas of these communities, regardless of the current level of development. Pumping stations and force mains are to be used in all facilities to transport effluent to the treatment plant. Secondary treatment is proposed for each facility, along with ocean disposal in Dare and Carteret Counties, spray disposal in Topsail/Surf City and Southwestern Brunswick County, and surface water discharge to the Cape Fear River in Southeastern Brunswick County.

The impacts of the 201 Strategy as determined by the EIS are:

1. Costs

a. This is the highest cost alternative. (The EIS case study found this alternative to cost approximately $12.0 million).

b. High capital and O&M costs will mean a large local financial burden both on municipalities and users.

2. Implementability

a. The costs and management skills associated with operating a centralized system require a more complex and sophisticated administration set-up than now exists in most of the barrier island local governments.

b. Centralized wastewater systems are susceptible to storm damage. Such damage could disrupt the entire wastewater system and result in more severe effects.

3. Reliability

a. Mechanical reliability is lower than under the EIS Strategy. Systems with many above ground structures are highly susceptible to storm damage. This susceptibility can be reduced by siting facilities on the mainland.

b. The reliability of treatment processes is high except in storm damage situations where the potential for adverse environmental impacts is high if the system fails.

c. The reliability of operation is high in centralized systems when well-trained operators are employed.

4. Primary Environmental Impacts

a. Construction impacts are community-wide and include effects on surface and groundwater, noise impacts, traffic disruption and short-term habitat destruction.

b. Groundwaters will not be subject to degradation from on-site systems.

c. The concentration of wastewater in one location can create adverse impacts resulting from: (1) damage of the system by storms, (2) impacts to surface and groundwaters from disposal and (3) unsatisfactory operation of the treatment plant.

5. Secondary Environmental Impacts

a. Increased population densities could result in increased pollution to surface water from stormwater runoff, thus adversely affecting shellfishing beds.

b. Sewering marginal land near sensitive natural areas would promote development, adversely impacting the plant and animal resources within these ecosystems.

c. There would be fewer wastewater management constraints on development activities.

d. High density beachfront development has the potential for reducing habitat for shorebirds, including the brown pelican, and may adversely impact loggerhead turtle nesting activity.

PART E. SUMMARY

The EIS Strategy is the proposed approach for wastewater management on the N. C. barrier islands for the draft EIS. The EIS Strategy is the only strategy which will provide for each of the EIS issues to be addressed in the planning process. This strategy should result in more cost effective and environmentally sound wastewater management system for North Carolina barrier island communities.

The EIS concluded that the 201 strategy would likely result in costly systems which would produce adverse secondary impacts to the natural environment and adverse financial impacts to local governments. The No Federal Action Strategy would leave certain water quality problems unresolved and would increase the probability of future problems because it would effectively eliminate the continuation of facilities planning.

The EIS Strategy incorporates the following beneficial features:

- The procedures promote documenting and then resolving existing water quality problems.
- The procedures promote sound planning for existing and future wastewater management needs.
- The procedures promote maximum local decision making and provide for disclosure of financial and institutional impacts.
- The procedures minimize costs to communities by promoting consideration of less expensive alternatives.

NORTH CAROLINA BARRIER ISLANDS
DRAFT ENVIRONMENTAL IMPACT STATEMENT
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20

METRIC CONVERSION CHART

1 inch (in.) = 2.54 centimeter (cm)	1 cm = 0.394 in.
1 foot (ft) = 0.305 meter (m)	1 m = 3.28 ft
1 mile (mi) = 1.61 kilometer (km)	1 km = 0.621 mi
1 square foot (ft^2) = 0.0929 square meter (m^2)	1 m^2 = 10.76 ft^2
1 acre (ac) = 0.405 hectare (ha)	1 ha = 2.47 ac
1 gallon (gal) = 3.79 liter (l)	1 l = 0.264 gal
1 million gallons per day (mgd) = 3,790 m^3/d	1 m^3/d = 0.000264 mgd
degrees F = 1.8°C + 32	degrees C = (F° - 32)(.555)

CHAPTER I. PURPOSE AND NEED FOR ACTION

Six 201 Facilities Plans which include barrier islands have been submitted to EPA for approval. These plans are Southwestern Brunswick County, Southeastern Brunswick County, Topsail/Surf City in Onslow County, Carteret County Complex, Hatteras Island in Dare County and Dare Beaches Complex in Dare County. Figure I.1 shows the location of these planning areas.

Five of the draft 201 Facilities Plans received by EPA propose the construction of wastewater collection, transportation and treatment facilities to serve large portions of these islands. The sixth plan, Hatteras Island, recommended that two regional systems be reconsidered at a later date when a larger population base made the systems cost-effective. After an environmental review of the proposed facilities plans, EPA had significant concerns about the potential impacts of these plans.

EPA funding for these proposed facilities has been determined to be a Major Federal Action significantly affecting the quality of the human environment, and therefore, the National Environmental Policy Act (NEPA) requires that an EIS be prepared. An areawide EIS was the most expeditious way of addressing the issues identified below and providing guidance for completing 201 Plans.

A. Background and Issues

Several key issues led to the decision to conduct this EIS for the North Carolina barrier islands. Many of these issues were identified by EPA during the review of the draft 201 Plans. Other issues were brought out during the scoping meeting in Raleigh, N.C. or at one of the three coastal scoping meetings. These issues are summarized as:

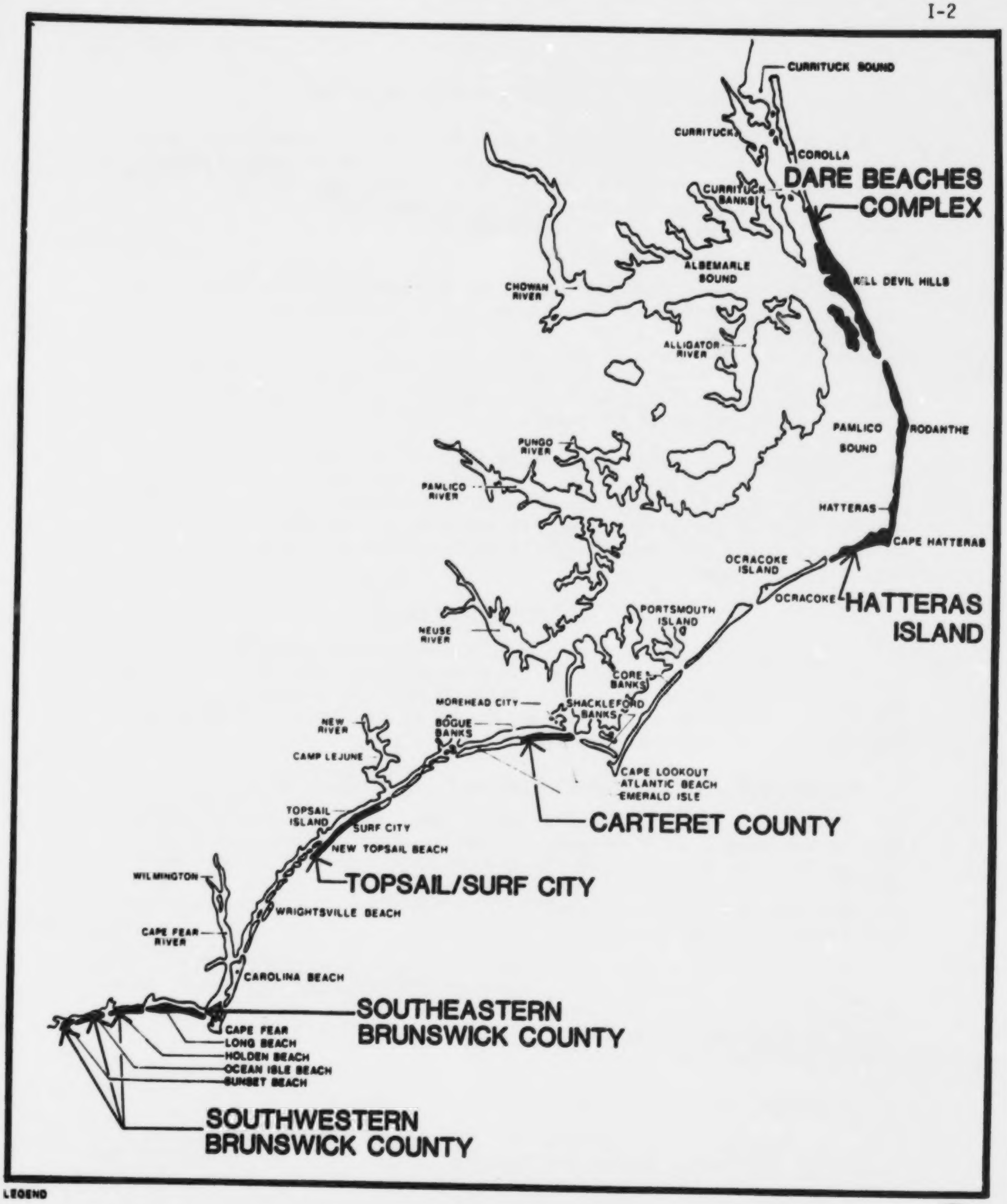
1. Surface Water Quality Impacts/Closing of Shellfish Beds

A need to identify existing areas of water pollution and the sources of that pollution has been recognized. The draft 201 Plans endeavored to justify the need for wastewater facilities on the barrier islands based on the pollution of shellfishing waters by failing septic tanks. Analysis of the data does not support this position except in a very few cases involving development on finger-fill canals.

Pollution on barrier islands could involve surface waters, either fresh or estuarine, or groundwater. Sources of pollution may be runoff from developed areas on the islands or mainland, sewage plant discharges, migratory waterfowl, malfunctioning septic tanks and/or discharges from vessels' sanitary facilities.

2. Groundwater Quality Impacts

The potential for contamination of shallow groundwater by soil absorption wastewater systems was analyzed by the EIS. An examination has been made of the quality and quantity of this resource as well as its current and potential use as a drinking water supply.


CURRITUCK SOUND
CURRITUCK
COROLLA
CURRITUCK BANKS
DARE BEACHES COMPLEX
ALBEMARLE SOUND
CHOWAN RIVER
KILL DEVIL HILLS
ALLIGATOR RIVER
PUNGO RIVER
PAMLICO SOUND
RODANTHE
PAMLICO RIVER
HATTERAS
CAPE HATTERAS
OCRACOKE ISLAND
OCRACOKE
HATTERAS ISLAND
PORTSMOUTH ISLAND
NEUSE RIVER
CORE BANKS
MOREHEAD CITY
SHACKLEFORD BANKS
NEW RIVER
BOGUE BANKS
CAMP LEJUNE
CAPE LOOKOUT
ATLANTIC BEACH
EMERALD ISLE
CARTERET COUNTY
TOPSAIL ISLAND
SURF CITY
NEW TOPSAIL BEACH
TOPSAIL/SURF CITY
WILMINGTON
WRIGHTSVILLE BEACH
CAPE FEAR RIVER
CAROLINA BEACH
SOUTHEASTERN BRUNSWICK COUNTY
CAPE FEAR
LONG BEACH
HOLDEN BEACH
OCEAN ISLE BEACH
SUNSET BEACH
SOUTHWESTERN BRUNSWICK COUNTY

LEGEND

Figure I.1 Barrier Islands Within 201 Facilities Plan Study Areas

3. Alternative Wastewater Management Technologies

While some septic tank failures are known and documented on the barrier islands, many areas have been served by septic tanks for years without problems. EPA has not only accepted functioning septic tanks and other on-site systems as permanent but may consider such alternative systems innovative and allow higher federal funding percentages than for conventional regional systems. EPA recognizes that regional systems may have significant adverse primary and secondary environmental impacts. Due to their nature, barrier islands could be more than ordinarily susceptible to these impacts.

All available technologies for wastewater management on the barrier islands were not evaluated by the 201 Plans. With effective management on-site and small community systems may provide appreciably more cost-effective alternatives that could support low, medium and potentially high density development.

4. Economic and Fiscal Impacts on Local Citizens and Governments

The significant seasonal and day use of barrier islands may lead to large financial impacts for permanent residents of small communities, who may find themselves providing funding for plant capacity which is needed only a few days per year. Operation and maintenance and replacement costs of centralized systems may also not be affordable, regardless of the extent of federal and state assistance in meeting capital costs.

5. Sensitive Natural Areas and Potential for Storm Damage

Barrier islands have special environmental characteristics which enhance both their value and their vulnerability. These attributes include:

- High direct exposure to the Atlantic Ocean and its storms
- Vulnerability to overwash and inlet formation and erosion or deposition
- Vulnerability of vegetation to wind-borne salt spray
- Salt marshes and freshwater marshes
- Sand dunes as part of a sand sharing system
- Maritime forests
- Fresh water existing as a lens subject to surface pollution or salt water intrusion.

A number of ecological niches have evolved on barrier islands which are infrequently encountered elsewhere and may be quite sensitive to disturbance. Similarly, the physical structures are often fragile and easily damaged by human uses and abuses. These attributes led to extensive state concern and legislation which EPA considered in alternatives development. Specific 201-related potential problems which merit individual study included:

- Sewer disruption by erosion/inlet formation
- Pollution of shellfish beds by point or nonpoint discharges
- Damage to sewage plants by storms
- Aquifer degradation by septic tanks or by nonpoint runoff
- Disruption of Areas of Environmental Concern* as a direct or indirect consequence of 201-derived actions.

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*Environmentally sensitive areas delineated by the N.C. Coastal Zone Management Program requiring special protection and management.

- Disruption of wildlife habitat areas
- Destruction of threatened or endangered species or their habitats.

The effectiveness of the North Carolina Coastal Area Management program is an important factor in addressing the impacts on sensitive natural areas.

6. Nonpoint Source Pollution

The provision of new wastewater management systems, particularly centralized or regional treatment plants, may promote higher density development, significantly increasing the potential for nonpoint source pollution of estuarine waters.

B. Existing Wastewater Management Systems

Existing wastewater management systems on barrier islands fall into three categories: 1) individual on-site systems, 2) treatment plants with surface discharge, and 3) treatment plants with subsurface disposal. Each category is described below.

1. Individual On-Site Systems

Most of the domestic wastewaters generated on or near the barrier islands are treated using septic tank soil absorption systems. These include the larger systems [greater than 11,280 l (3,000 gal) per day] permitted prior to January 1, 1982, by the Division of Environmental Management (DEM) that serve commercial establishments as well as smaller systems permitted by the county health departments that serve small commercial establishments and residences. Estimates by the EIS of the 1980 peak summer populations served by on-lot disposal systems indicate that these 128,078 persons generate a wastewater discharge of approximately 9.0-10.0 mgd.

2. Treatments Plants With Surface Discharge

The Villas and Ocean Sands package plants in Dare County and the Wrightsville Beach municipal plant discharge to SC (suitable for recreation) waters that could be classified SA (suitable for shellfish harvesting) if not for the wastewater discharge. These discharges were in existence prior to the classification of the state's waters. When the waters were classified, limited areas around the existing discharges were classified SC instead of SA to reflect the existing use of the waters for treated waste assimilation. The US Coast Guard stations at Oregon Inlet and Hatteras Inlet do, however, discharge to SA waters.

With the exception of a few wastewater treatment facilities and one laundromat at Buxton, all industrial wastewater discharges are associated with some type of fish/seafood processing wastes. These facilities often discharge to SA waters, but no water quality violations have been associated with the existing industrial discharges. Therefore, these industrial discharges are generally not considered a major influence on water quality.

One of the most significant industrial developments is the large seafood processing center and shipyard at Wanchese. When operations begin, this will be the largest concentration of industrial activity in the immediate vicinity of barrier islands. A 1,428.8 m^3/d (0.377 mgd) advanced secondary treatment plant has been constructed to handle wastewaters from these seafood processors.

3. Treatment Plants With Sub-Surface Disposal

Community sub-surface disposal systems are found on barrier islands in three 201 planning areas. Southeastern Brunswick County has three systems, Carteret County supports systems on Bogue Banks, and Dare Beaches has eight sub-surface disposal facilities. These systems were regulated by DEM prior to July 1, 1982, which mandated specific maintenance and operations procedures. Presently the systems are regulated by the local health departments. The costs associated with all aspects of plant construction, operation, and maintenance are the responsibility of the property owners.

Because the discharge of treated domestic wastewaters to SA waters has been prohibited by state regulation, newer package plants discharge to the water table aquifer, either by subsurface nitrification fields or distribution on the surface sands. These systems generally provide advanced treatment of wastewaters consisting of secondary biological treatment followed by solids removal prior to disposal.

Nitrification fields are used extensively in barrier islands communities. However, the package plant serving the Holiday Inn at Nags Head is an example of the rotary distribution system alternative. Both types of systems are generally referred to as non-discharge systems because they do not discharge to surface waters.

C. Summary of Draft 201 Plans

The 201 Facilities Plans proposed for North Carolina's barrier islands exhibit a number of similarities. Each plan calls for the replacement of existing on-site wastewater treatment systems with centralized collection, transmission, treatment and disposal facilities. Justification for this structural solution is found in reports of shellfish harvest area closings due to elevated fecal coliform counts and is based on the prediction that continued rapid residential and commercial development using on-site systems would lead to additional shellfish area closings. Localized studies in finger-fill canal developments have determined that existing on-site soil absorption systems have caused water quality problems. The reasons for these few on-site system failures have been attributed to high groundwater tables, faulty installation, poor maintenance, and unsuitable soils.

Another similarity is the proposal to provide sewer lines to all areas of the identified communities, regardless of the current level of development. Sewer availability will then be provided for all future development. In all cases, the individual collection systems are to be designed and constructed by each local jurisdiction. Pumping stations and force mains are to be used in all facilities to transport effluent to the treatment plant. Secondary treatment would be provided at each plant prior to ocean disposal in Dare and Carteret counties, spray disposal in Topsail/Surf City and Southwest Brunswick County, and surface water discharge to the Cape Fear River in Southeast Brunswick County.

Each of the wastewater treatment systems proposed for the barrier islands (except Hatteras Island) is considered economically feasible by local officials as presented in the draft plan. However, the cost figures which have been developed cover only those portions of the treatment facilities (transmission, treatment, and disposal) which are eligible for federal funding. Costs for individual collection systems for each area and ocean outfalls for Carteret and Dare Counties have not been factored into the figures presented in the draft 201 Plans.

All of the draft 201 Plans anticipated that at least 75 percent federal funding (85 percent for alternative and innovative system components) will be available for Step 2 and Step 3 activities. State funds for conventional systems (12.5 percent) and innovative systems (7.5 percent) are also expected to be available, leaving the remaining costs to be borne by the local participants. The details of this funding source, how it is accessed, and when and where it may be applied are not discussed in any of the 201 Plans.

The 1981 Amendments to the Clean Water Act have changed the federal funding level for construction grants. After October 1, 1984, grants of 55 percent will be made for the construction of treatment works. An additional 20 percent will be available for alternative and innovative systems, but in no case will the grant exceed 85 percent. The innovative and alternative system funding program has been extended through FY 1984.

The local share of funds in each plan is to be generated by issuing general obligation bonds for system construction. In each plan locally administered user charges, based on the estimated monthly volume of effluent, will provide sufficient revenue to cover the local share of the debt service and annual operations and maintenance costs. User charges were projected on a household basis that does not differentiate between permanent and seasonal residents. User charges were also based on a constant volume use that would not hold true for seasonal residences, which constitute the majority of the housing stock on the barrier islands.

The annual debt service for each facility is calculated for the estimated grant eligible systems components and is based on the interest rate prevailing at the time the plan was prepared. Subsequent inflationary pressures have significantly increased design and construction costs for several plans. The interest rate has also risen.

Costs for system components not covered by federal funding have not been determined by most 201 Plans. These costs for collection systems and ocean outfalls have also increased and will have to be addressed by the individual local governments before proceeding further.

Four of the proposed 201 Plans provided schedules of necessary steps for project implementation, but the Southeastern Brunswick County plan did not address implementation procedures. Operations and maintenance needs were discussed in each of the 201 Plans. The level of detail varied but general manpower requirements, equipment needs, and annual O&M costs were presented in each plan. Maintenance manuals for each system would be prepared as part of the Step 2 detailed design phase.

The Dare Beaches 201 Plan is the only plan to specifically identify individual responsibilities for each constituent government. This plan gives recommended construction, operation and maintenance tasks to each party and indicates negotiable arrangements that must be resolved before construction can begin. The other plans note that arrangements are necessary, but they do not assign responsibilities.

Both the Dare Beaches and Carteret County plans have evaluated and recommended agencies legally eligible to administer the operations of the proposed facilities. The Topsail/Surf City, Southwest Brunswick County and Southeastern Brunswick County plans did not recommend a particular agency structure, although the need for such an organization is recognized as a necessary element for proceeding to Step 2 design.

A description of each 201 Plan is found in Chapter II.

CHAPTER II. DESCRIPTION OF ALTERNATIVE STRATEGIES AND IMPACTS

This EIS developed and evaluated reasonable alternative strategies for wastewater management on the barrier islands of North Carolina. The three strategies developed represent distinctly different approaches to the planning process used by local governments to select appropriate treatment facilities and financial and institutional arrangements.

The three strategies are referred to as the No Federal Action, 201 and EIS strategies. Under the No Federal Action Strategy, no federal funding would be available to support wastewater management system development on the barrier islands. Under the 201 Strategy, the five draft 201 Plans would be implemented largely as submitted after cost factors have been updated. Under the EIS Strategy, grant applicants would update draft 201 Plans using procedures designed by the EIS to account for the unique environmental and socioeconomic conditions prevailing on barrier islands. The EIS is presenting the EIS Strategy as the preferred approach to wastewater management on the North Carolina barrier islands. Each alternative strategy will be discussed in turn, starting with the preferred approach.

A. EIS Strategy (Preferred Approach)

The EIS Strategy is composed of procedures developed by this EIS which are intended to refine procedures normally undertaken in the preparation of a 201 Plan. These additional procedures are proposed in response to the needs of North Carolina barrier islands which are characterized by extensive environmentally sensitive areas, highly fluctuating populations and limited financial resources.

The procedures are consistent with 201 Construction Grants regulations and other facilities plan preparation guidance; however, they are tailored and refined to address the unique environmental and socioeconomic conditions on the North Carolina barrier islands. The procedures were designed to address the six issue areas identified in Chapter I. Special attention was given to two areas which were most lacking in the draft 201 Plans: a thorough evaluation of all wastewater technologies, especially on-site and small community systems, and the financial and institutional impacts of operating and maintaining wastewater management systems.

1. Description of the Strategy

The supplemental procedures fall into three major groupings and each is discussed in turn:

- Procedures for determining need and estimating flows
- Procedures for developing alternative wastewater management systems
- Procedures for evaluating alternative wastewater management systems

An effort has been made to communicate these procedures in narrative and graphic form. Figure II.1 presents an overview of the EIS Strategy. Each rectangle in the flow chart represents a separate procedure. The following sections of this chapter describe these procedures and contain detailed flow

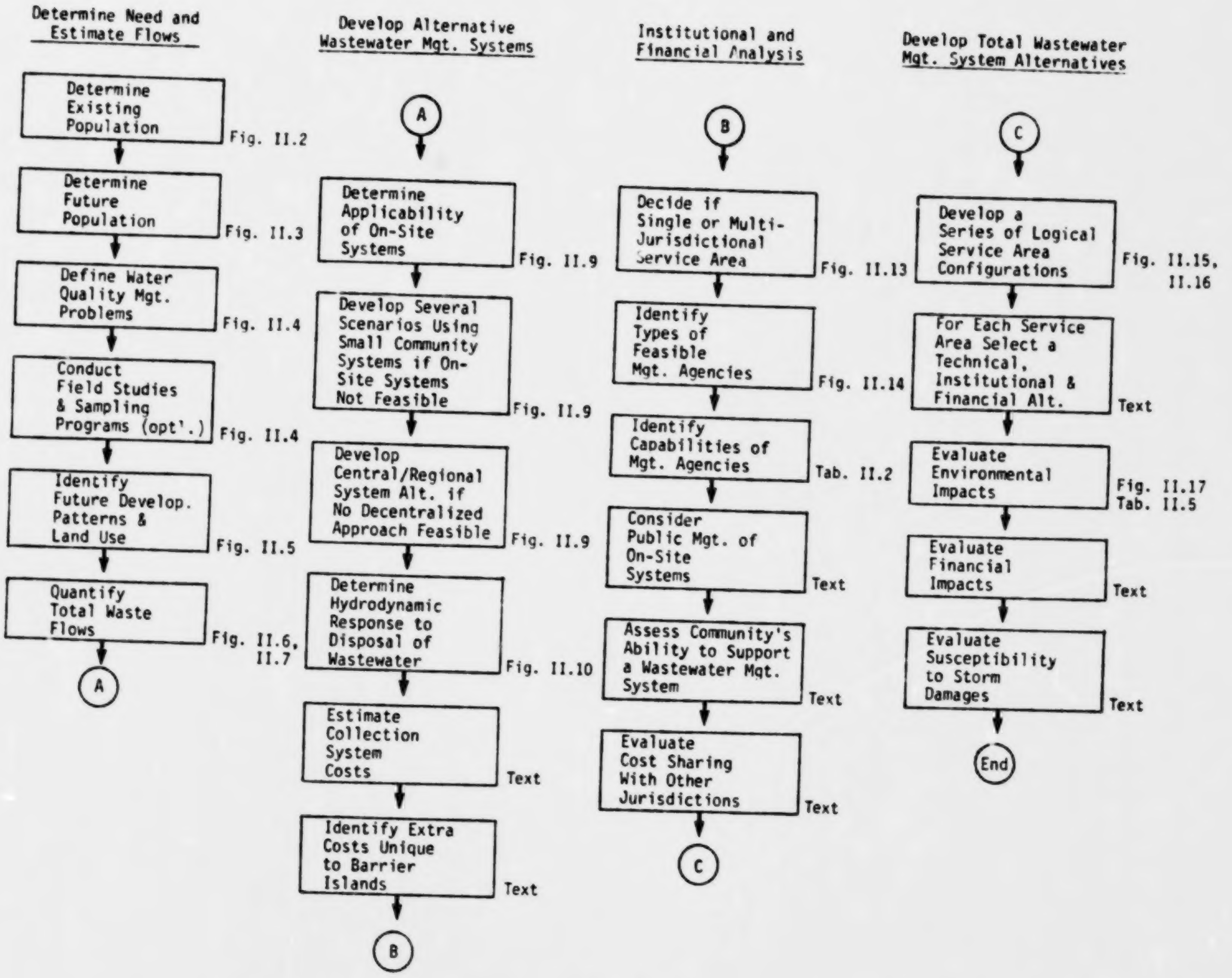

Determine Need and Estimate Flows
Determine Existing Population
Fig. II.2
Determine Future Population
Fig. II.3
Define Water Quality Mgt. Problems
Fig. II.4
Conduct Field Studies & Sampling Programs (opt'.)
Fig. II.4
Identify Future Develop. Patterns & Land Use
Fig. II.5
Quantify Total Waste Flows
Fig. II.6, II.7
A
Develop Alternative Wastewater Mgt. Systems
A
Determine Applicability of On-Site Systems
Fig. II.9
Develop Several Scenarios Using Small Community Systems if On-Site Systems Not Feasible
Fig. II.9
Develop Central/Regional System Alt. if No Decentralized Approach Feasible
Fig. II.9
Determine Hydrodynamic Response to Disposal of Wastewater
Fig. II.10
Estimate Collection System Costs
Text
Identify Extra Costs Unique to Barrier Islands
Text
B
Institutional and Financial Analysis
B
Decide if Single or Multi-Jurisdictional Service Area
Fig. II.13
Identify Types of Feasible Mgt. Agencies
Fig. II.14
Identify Capabilities of Mgt. Agencies
Tab. II.2
Consider Public Mgt. of On-Site Systems
Text
Assess Community's Ability to Support a Wastewater Mgt. System
Text
Evaluate Cost Sharing With Other Jurisdictions
Text
C
Develop Total Wastewater Mgt. System Alternatives
C
Develop a Series of Logical Service Area Configurations
Fig. II.15, II.16
For Each Service Area Select a Technical, Institutional & Financial Alt.
Text
Evaluate Environmental Impacts
Fig. II.17 Tab. II.5
Evaluate Financial Impacts
Text
Evaluate Susceptibility to Storm Damages
Text
End

Figure II.1 Overview of EIS Strategy

30<

charts for each procedure. Histograms, matrices and other diagrams are included where appropriate to provide maximum visual parallels to written materials.

a. Procedures for Determining Need and Estimating Flows

The first subroutine in Figure II.1 graphically depicts the procedures appropriate to determine the need for wastewater management systems and to quantify flows. Determining the need and estimating flows which require additional wastewater management consists of identifying those portions of existing and projected populations that cannot be adequately served by current wastewater management strategies. Essentially, population that cannot be adequately served by current wastewater management strategies is that population whose wastewater management strategies either cause water quality problems or will cause water quality problems when the population served increases.

The first step is to quantify existing population served by existing wastewater management strategies. This task tends to be difficult on the barrier islands because the resident population component is a small fraction of the summer peak which includes seasonal residents, overnight visitors and day visitors. Thereafter, projections must be made of these population components for five-year intervals during the planning period. Figure II.2 explains this methodology and shows how the four population components are calculated.

Having determined the existing population, the future population to be served must then be determined. This is accomplished by disaggregating the 1980 Census data for the study area and then calculating ratios of seasonal, overnight and day visitors to permanent residents. These ratios are then used with projections of the permanent residents to determine future population by component. Figure II.3 diagrams these steps.

Next, areas of existing development which are experiencing problems and are in need of new or improved wastewater management systems are identified. This is accomplished by defining water quality problems and by conducting an inventory of actual conditions in the study area. Figure II.4 illustrates these tasks and shows how decisions are reached as to whether wastewater management systems are needed.

Future development patterns are determined by conducting an inventory of areas that can be used for future development in the study area. These areas will be lands on which CAMA has not restricted development, but the exact nature of the development of these lands will be affected by zoning and other restrictions. Approved population projections should be given careful consideration in defining future development patterns. Figure II.5 shows these steps.

Knowing or having calculated existing and future populations, existing development in need of wastewater management and future development patterns, total flows requiring wastewater management can be determined. This is accomplished by determining existing flows from either existing water use and existing wastewater treatment records or by multiplying population components by prescribed daily wastewater flow estimates. Similar ratios are

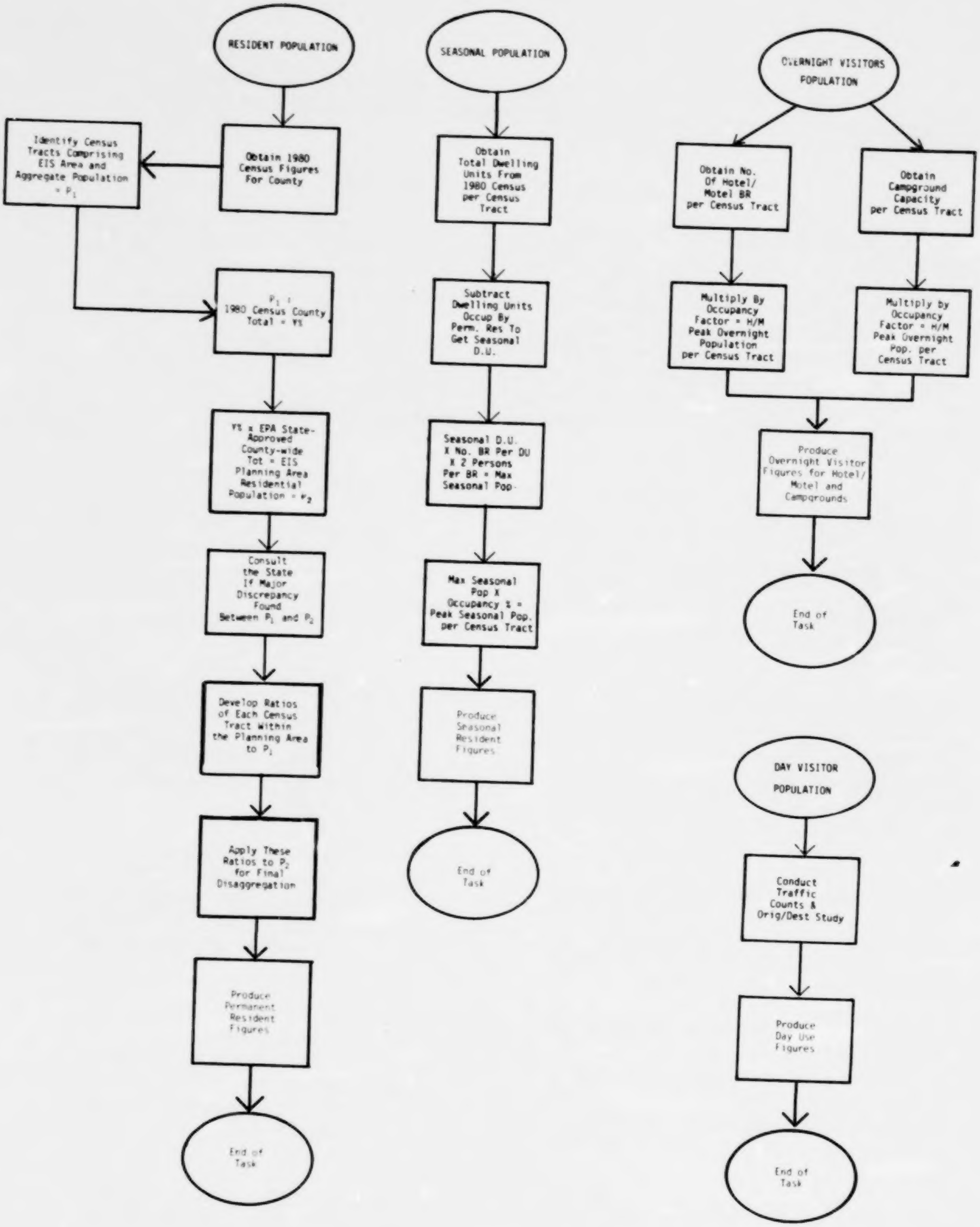
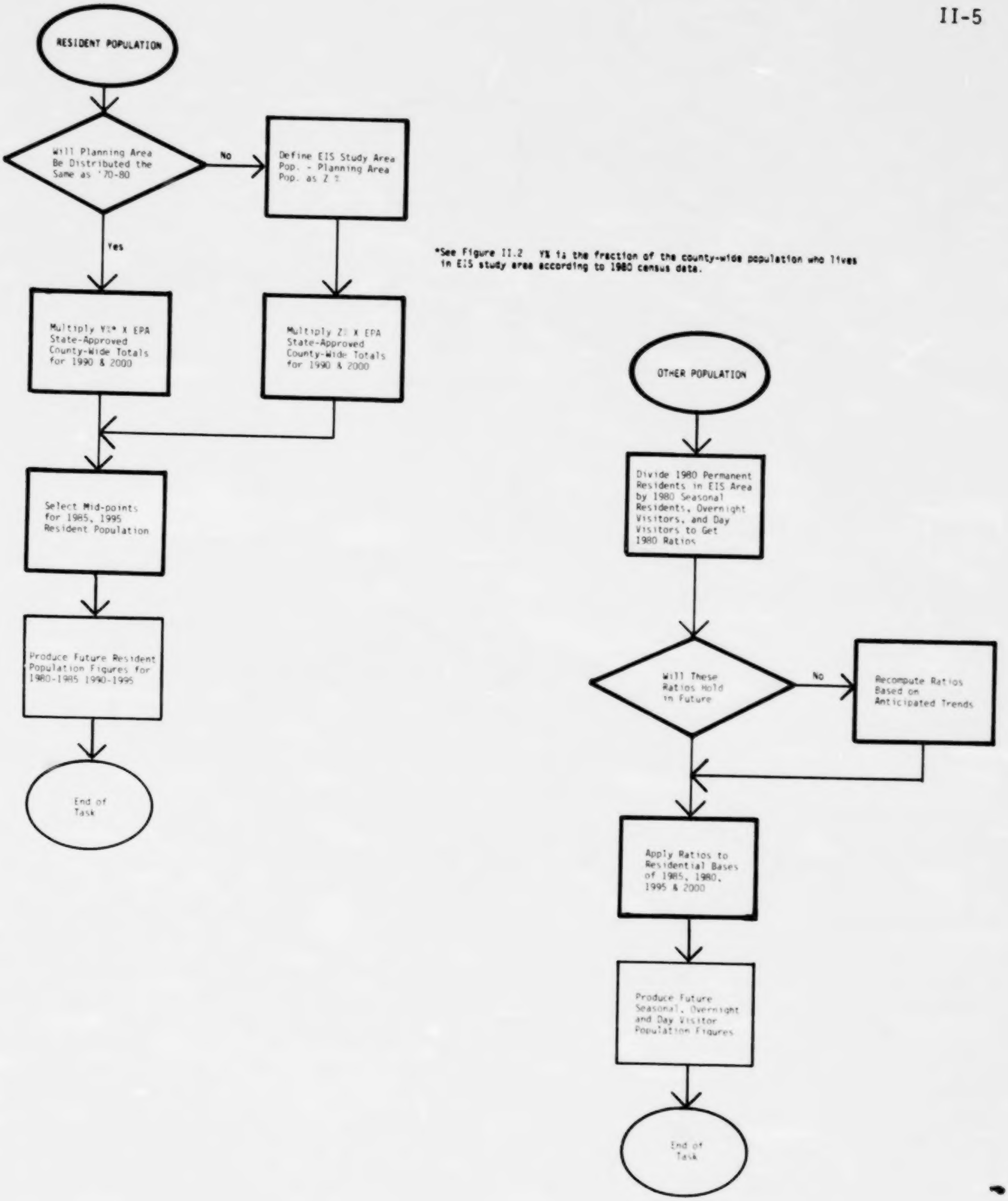

RESIDENT POPULATION
Obtain 1980 Census Figures For County
Identify Census Tracts Comprising EIS Area and Aggregate Population = P1
P1 = 1980 Census County Total = Y%
Y% x EPA State-Approved County-wide Tot = EIS Planning Area Residential Population = P2
Consult the State If Major Discrepancy Found Between P1 and P2
Develop Ratios of Each Census Tract Within the Planning Area to P1
Apply These Ratios to P2 for Final Disaggregation
Produce Permanent Resident Figures
End of Task
SEASONAL POPULATION
Obtain Total Dwelling Units From 1980 Census per Census Tract
Subtract Dwelling Units Occup By Perm. Res To Get Seasonal D.U.
Seasonal D.U. X No. BR Per DU X 2 Persons Per BR = Max Seasonal Pop.
Max Seasonal Pop X Occupancy % = Peak Seasonal Pop. per Census Tract
Produce Seasonal Resident Figures
End of Task
OVERNIGHT VISITORS POPULATION
Obtain No. Of Hotel/Motel BR per Census Tract
Obtain Campground Capacity per Census Tract
Multiply By Occupancy Factor = H/M Peak Overnight Population per Census Tract
Multiply by Occupancy Factor = H/M Peak Overnight Pop. per Census Tract
Produce Overnight Visitor Figures for Hotel/Motel and Campgrounds
End of Task
DAY VISITOR POPULATION
Conduct Traffic Counts & Orig/Dest Study
Produce Day Use Figures
End of Task

Figure II.2 Methodology for Calculating Existing Population

Source: Claude Terry & Associates, Inc., 1981


RESIDENT POPULATION
Will Planning Area Be Distributed the Same as '70-80
No
Define EIS Study Area Pop. - Planning Area Pop. as Z %
Yes
Multiply Y%* X EPA State-Approved County-Wide Totals for 1990 & 2000
Multiply Z% X EPA State-Approved County-Wide Totals for 1990 & 2000
Select Mid-points for 1985, 1995 Resident Population
Produce Future Resident Population Figures for 1980-1985 1990-1995
End of Task
OTHER POPULATION
Divide 1980 Permanent Residents in EIS Area by 1980 Seasonal Residents, Overnight Visitors, and Day Visitors to Get 1980 Ratios
Will These Ratios Hold in Future
No
Recompute Ratios Based on Anticipated Trends
Apply Ratios to Residential Bases of 1985, 1980, 1995 & 2000
Produce Future Seasonal, Overnight and Day Visitor Population Figures
End of Task

*See Figure II.2 Y% is the fraction of the county-wide population who lives in EIS study area according to 1980 census data.

Figure II.3 **Methodology for Calculating Future Population.**
Source: Claude Terry & Associates, Inc., 1981

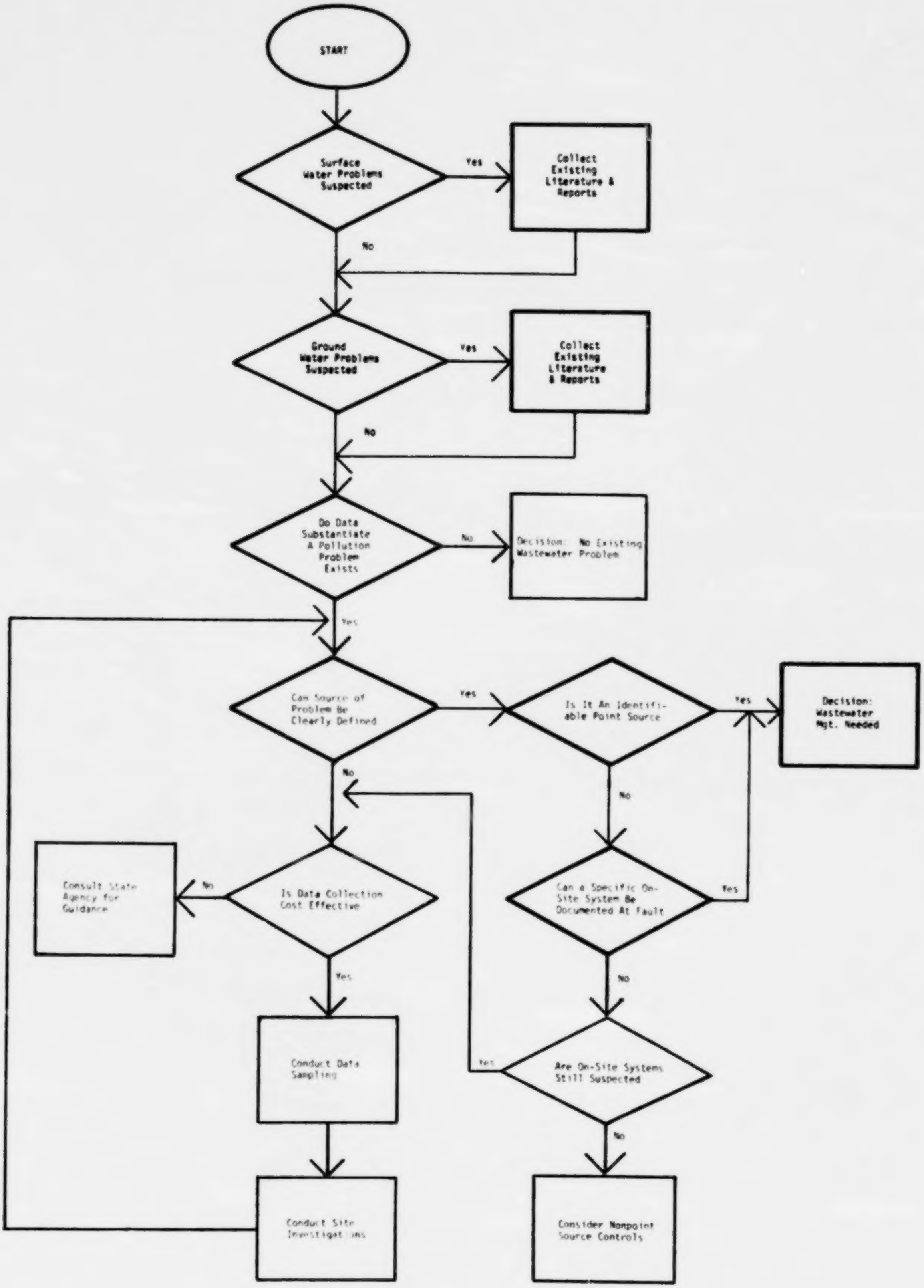
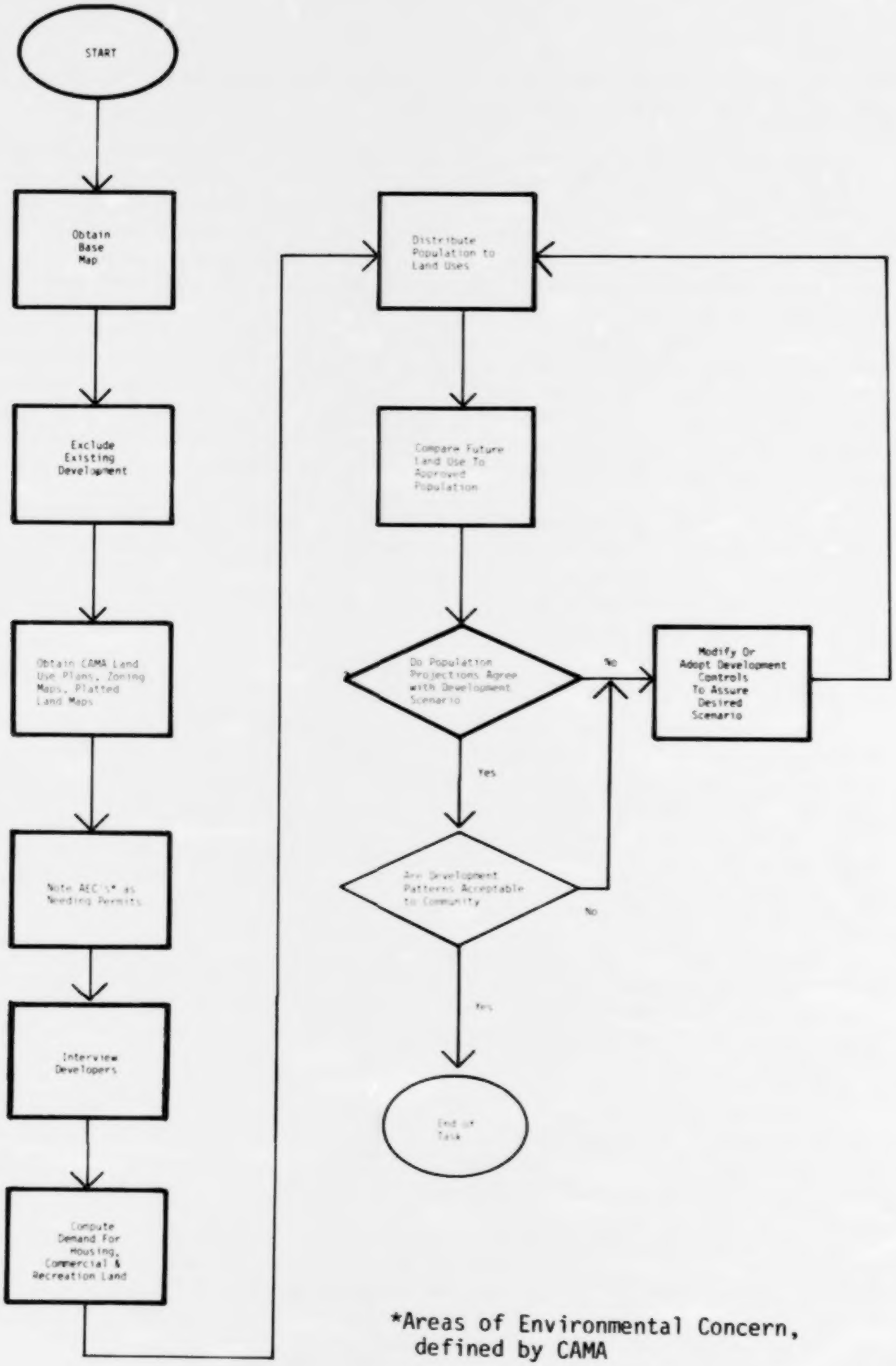

START
Surface Water Problems Suspected
Yes
Collect Existing Literature & Reports
No
Ground Water Problems Suspected
Yes
Collect Existing Literature & Reports
No
Do Data Substantiate A Pollution Problem Exists
No
Decision: No Existing Wastewater Problem
Yes
Can Source of Problem Be Clearly Defined
Yes
Is It An Identifiable Point Source
Yes
Decision: Wastewater Mgt. Needed
No
No
Consult State Agency for Guidance
No
Is Data Collection Cost Effective
Can a Specific On-Site System Be Documented At Fault
Yes
Yes
No
Conduct Data Sampling
Yes
Are On-Site Systems Still Suspected
No
Conduct Site Investigations
Consider Nonpoint Source Controls

Figure II.4 Methodology for Determining Existence of Water Quality Management Problems

Source: Claude Terry & Associates, Inc., 1981


START
Obtain Base Map
Exclude Existing Development
Obtain CAMA Land Use Plans, Zoning Maps, Platted Land Maps
Note AEC's* as Needing Permits
Interview Developers
Compute Demand For Housing, Commercial & Recreation Land
Distribute Population to Land Uses
Compare Future Land Use To Approved Population
Do Population Projections Agree with Development Scenario
No
Modify Or Adopt Development Controls To Assure Desired Scenario
Yes
Are Development Patterns Acceptable to Community
No
Yes
End of Task

*Areas of Environmental Concern, defined by CAMA

Figure II.5 Methodology for Identifying Future Development in Need of Wastewater Management

Source: Claude Terry & Associates, Inc., 1981

then used for projecting flows for future developments. The total flow is the sum of the current and future flows.

The development of flow projections on the North Carolina barrier islands is complicated by the fact that two types of peak flows must be considered. First, island communities experience extreme seasonal peak flows between winter and summer users. Then, within the summer peak season, additional peak flows result from tourism peaks such as Fourth of July weekend and other events. Consideration should be given to peak and average flows per month as well as expected daily, weekly or yearly fluctuations. In conclusion, the four population components (permanent residents, seasonal residents, overnight visitors and day visitors) are known to generate widely fluctuating flows by time period. These fluctuations have significant implications when user fees are being set. Figure II.6 illustrates a methodology for quantifying total flows. A final step is identifying and applying flow and waste reduction measures, as shown in Figure II.7.

The preceeding systems flow charts are taken from the Technical Reference Document, Alternatives Development Report, which contains detailed explanations of the actions and decisions in the flow charts. Additional systems flow charts will be found in later sections of this document and are taken from the same source.

b. Procedures for Developing Alternative Wastewater Management Systems

The EIS procedures systematically identify and screen all feasible wastewater management system alternatives. The resulting strategy coordinates information on existing systems' performance, existing and/or potential pollution problems, physical conditions and constraints of the area, and local governments' institutional and financial capabilities. The procedures that make up the integrated development strategy were designed to delete unfeasible alternatives from detailed investigation without excluding viable alternatives from further evaluation.

Figure II.8 is an overview of the procedures used to develop alternative wastewater management systems. The first step is the identification of potentially feasible subsystems. These subsystems address the various technical components of a wastewater management system and include facilities for the following:

- Collection of wastewater
- Treatment of wastewater
- Disposal of treated wastewater effluent
- Handling/disposal of sludge and/or septage generated by the systems.

To facilitate the process, information on existing systems along with documentation of identified pollution problems is incorporated to determine the extent of pollution due to the inadequacy of existing systems. The identification of reasonable alternatives to existing systems is then performed based on actual conditions in the area.

After this process, combining of subsystems into overall systems can be initiated. This step involves the development of the technical components previously identified into viable system alternatives based on the charac-

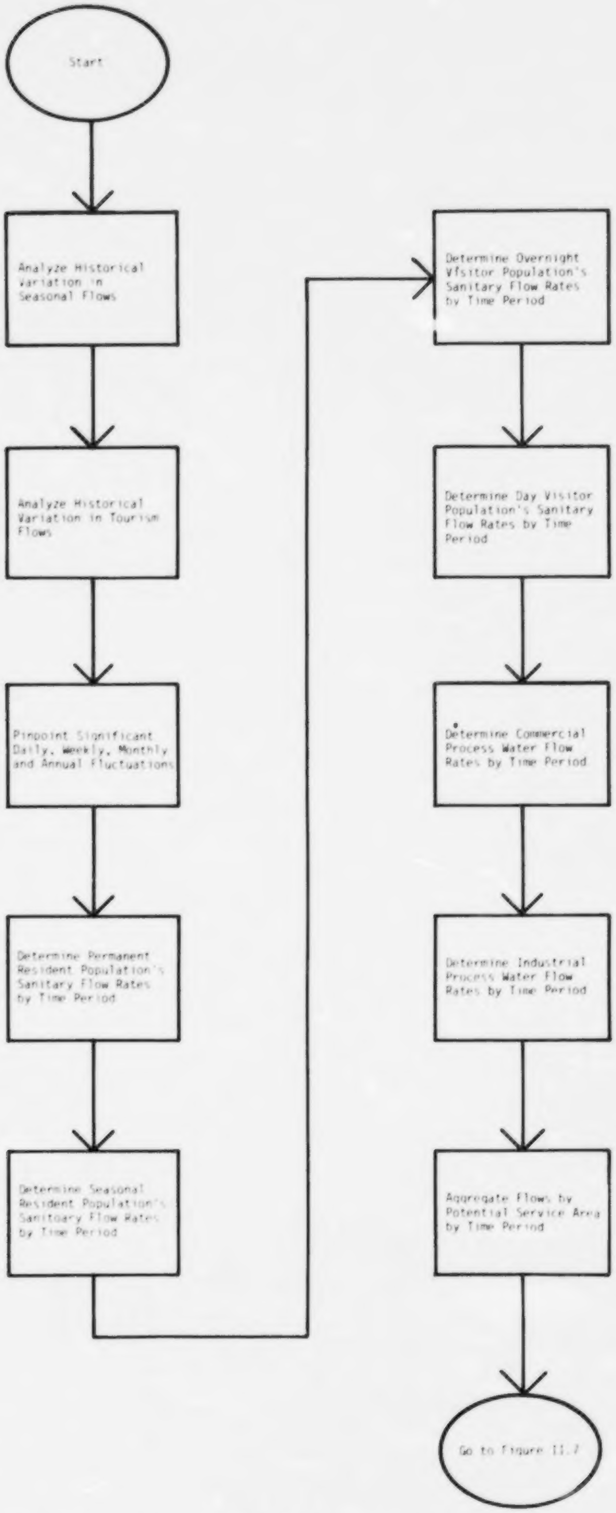

Start
Analyze Historical Variation in Seasonal Flows
Analyze Historical Variation in Tourism Flows
Pinpoint Significant Daily, Weekly, Monthly and Annual Fluctuations
Determine Permanent Resident Population's Sanitary Flow Rates by Time Period
Determine Seasonal Resident Population's Sanitoary Flow Rates by Time Period
Determine Overnight Visitor Population's Sanitary Flow Rates by Time Period
Determine Day Visitor Population's Sanitary Flow Rates by Time Period
Determine Commercial Process Water Flow Rates by Time Period
Determine Industrial Process Water Flow Rates by Time Period
Aggregate Flows by Potential Service Area by Time Period
Go to Figure II.7

Figure II.6 Methodology for Quantifying Total Flows

Source: Gannett Fleming Corddry and Carpenter, Inc., 1981.

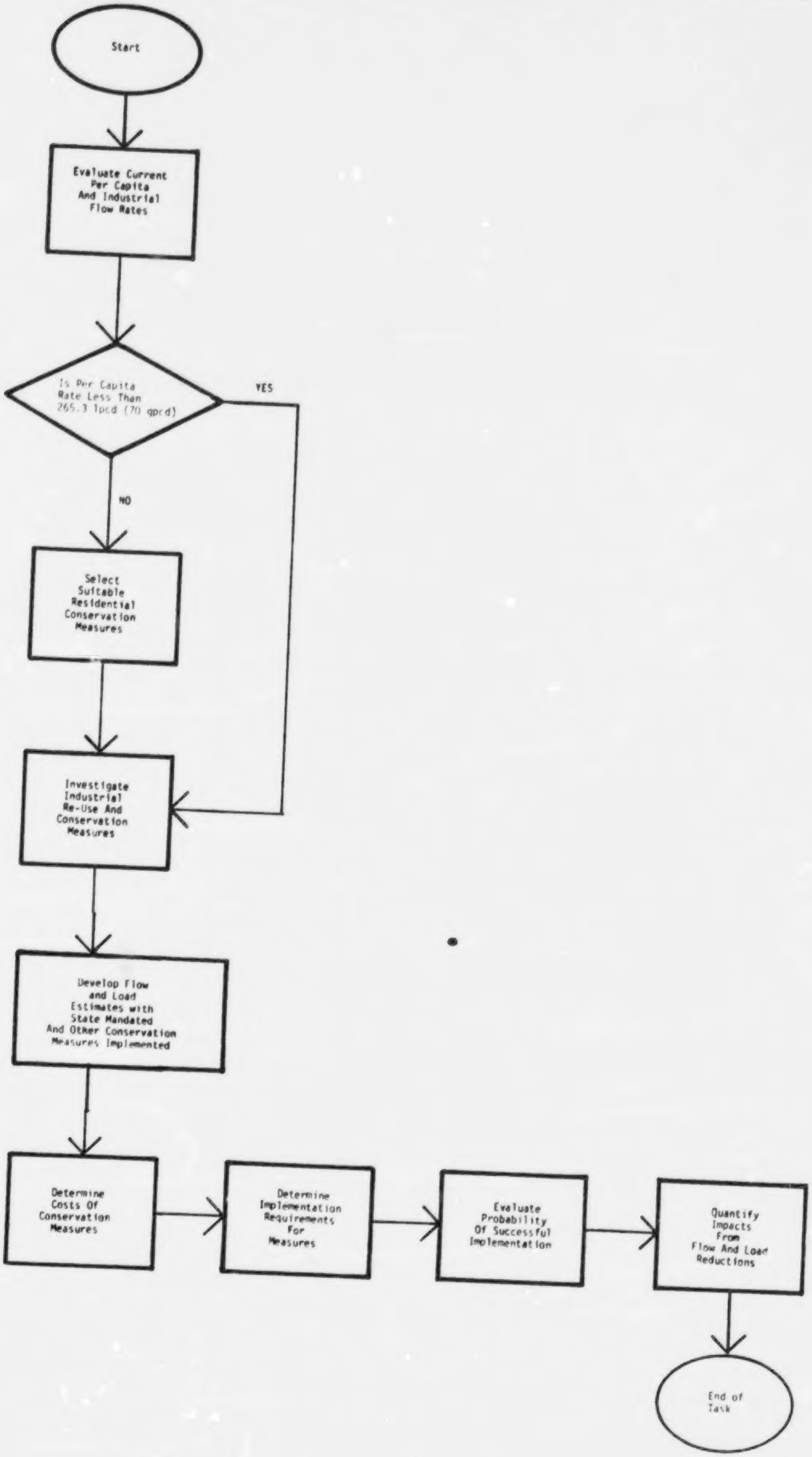

Start
Evaluate Current Per Capita And Industrial Flow Rates
Is Per Capita Rate Less Than 265.3 lpcd (70 gpcd)
YES
NO
Select Suitable Residential Conservation Measures
Investigate Industrial Re-Use And Conservation Measures
Develop Flow and Load Estimates with State Mandated And Other Conservation Measures Implemented
Determine Costs Of Conservation Measures
Determine Implementation Requirements For Measures
Evaluate Probability Of Successful Implementation
Quantify Impacts From Flow And Load Reductions
End of Task

Figure II.7 Methodology For Quantifying Flow and Waste Reduction Impacts

Source: Gannett Fleming Corddry and Carpenter, Inc., 1981.

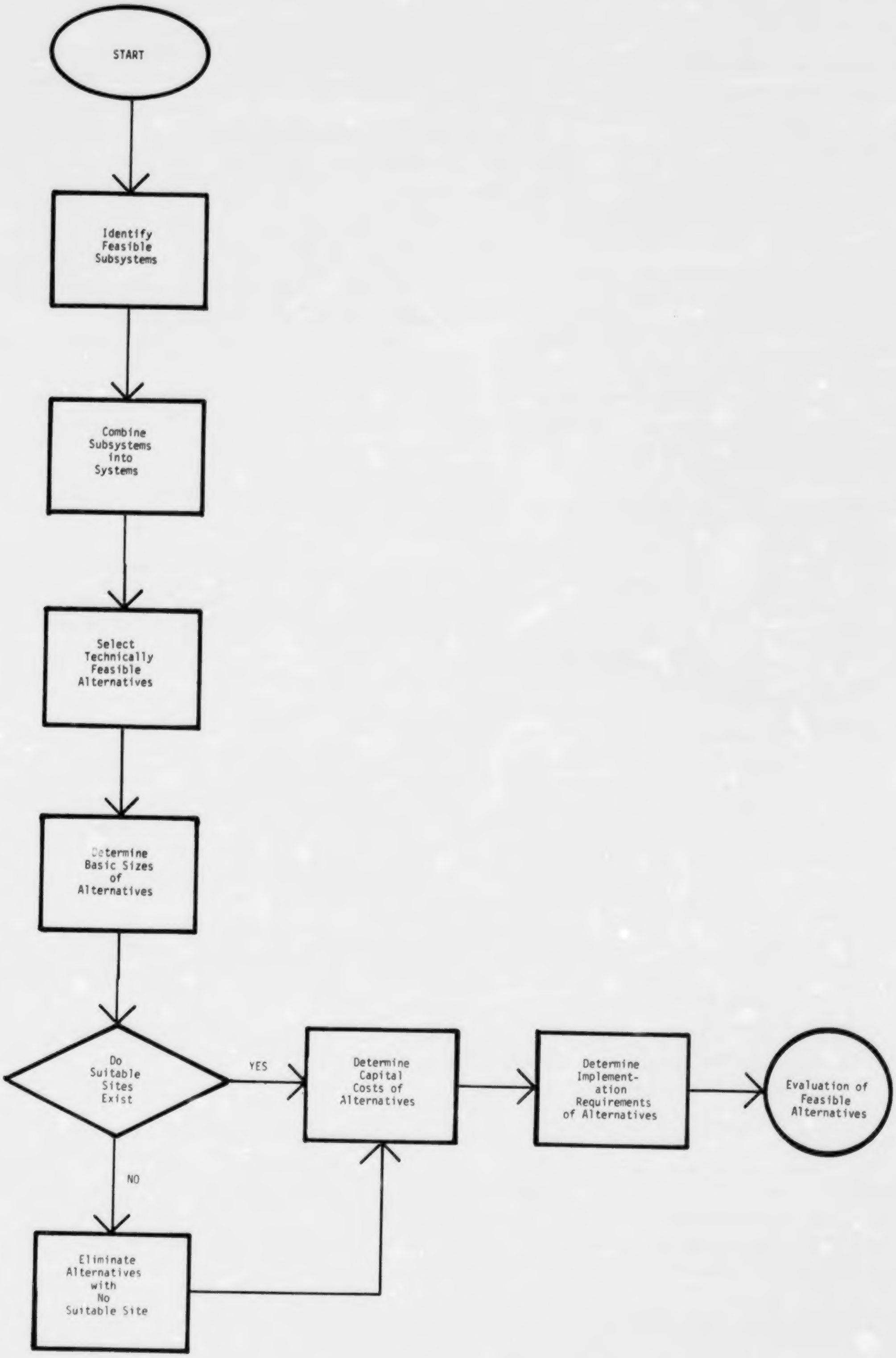

START
Identify Feasible Subsystems
Combine Subsystems into Systems
Select Technically Feasible Alternatives
Determine Basic Sizes of Alternatives
Do Suitable Sites Exist
YES
NO
Determine Capital Costs of Alternatives
Determine Implementation Requirements of Alternatives
Evaluation of Feasible Alternatives
Eliminate Alternatives with No Suitable Site

Figure II.8 Methodology for Developing Alternative Wastewater Management Systems

Source: Gannett Fleming Corddry and Carpenter, Inc., 1981.

teristics of the various technical components. To ensure that a complete list of feasible alternatives is identified for projected development densities and patterns, consideration is given to the various degrees of system centralization. The overall system alternatives are therefore categorized into four types of systems: individual on-site systems, community systems, central/regional systems and mixes of these previous three options.

The use of four categories of treatment/disposal systems is intended to facilitate the screening process which is the next step in the development of alternatives. This step results in the development of the principal technical alternatives. Screening of the feasible alternatives identified is to be based on system characteristics and requirements, specified site conditions and design factors, after which the system alternatives not eliminated will be analyzed according to their implementation requirements. From this point, the total system alternatives are to be subjected to cost-effectiveness analysis and evaluation.

(1) Description of Technologies Appropriate for Wastewater Management on Barrier Islands

In the identification of reasonable alternatives for wastewater management systems, the general physical conditions of barrier islands were considered in order to include only those system alternatives that would be compatible with the study area. These general conditions include the following:

- Geology dominated by unconsolidated sediments
- Topography generally consisting of beaches, dunes, and flats
- Soils principally granular in structure, ranging from deep and excessively well-drained to shallow, poorly drained and subject to flooding
- Moderate climate with fairly uniform temperature, precipitation, wind speed and relative humidity with intermittent occurrences of tropical storms, hurricanes and northeasters
- Groundwater regime consisting of a lighter freshwater lens floating atop the heavier salt water; water table depths are highly variable but generally tend to be very shallow due to seasonal high groundwater levels
- Primary surface waters are salt and brackish waters that are a mixture of saltwater from the ocean and fresh water from inland runoffs forming a complex hydrological system.

In order to allow for anticipated development densities and patterns, the potentially feasible alternatives were categorized into three types of systems. Table II.1 is a summary of the alternatives' technical components that were identified and include all the technical components that make up a wastewater management system. The following subsections provide a general description of each system type.

(a) Individual Systems

These systems are used by the individual homeowner or small commercial establishment. Historically, they have worked well in barrier island communities. Where such systems are properly installed, operated and maintained,

Table II.1 Sumary of Wastewater Treatment/Disposal System Alternatives

System Type	Collection Options	Wastewater Treatment/Disposal Options	Sludge/Septage Treatment Options
Individual		1. Septic Tank/Conventional Soil Absorption Field 2. Septic Tank/Modified Conventional Soil Absorption Field 3. Septic Tank/Low Pressure Piping System 4. Septic Tank/Mound System 5. Septic Tank/Artificially Drained System (High Water table is lowered) 6. Septic Tank/Evapotranspiration (ET) Bed 7. Septic Tank/Evaporation Lagoon (E) 8. Septic Tank Polishing/Surface Discharge 9. Aerobic Treatment Units/Non-Surface Disposal (soil absorption field, mound system, ET bed, E lagoon) 10. Aerobic Treatment Units/Surface Discharge 11. Holding Tank for Temporary Storage of Wastewater and Later Transport (Usually via Tank Truck) to Central Disposal Site. 12. In-House Wastewater Treatment and Recycle (incl. Composting Toilets) 13. Wastewater Segregation and Reuse	1. Land Application of Sludge/Septage 2. Sludge Landfilling-Area Fill 3. Sludge Storage 4. Sludge Landfilling-Trenching 5. Sludge/Septage Lagoon 6. Co-Incineration 7. Composting Sludge/Septage 8. Septage Treatment/Disposal 9. Conventional Landfill
Community	1. Small Diameter Gravity Sewers 2. Vacuum Sewers 3. Pressure Sewer, STEP (Septic Tank Effluent Pump) 4. Pressure Sewer, GP (Grinder Pump) 5. Conventional Gravity Sewers	1. Community Soil Absorption Field 2. Community Septic Tank & Mound System 3. Community Evaporation and Evaporation/Infiltration Lagoons 4. Multiple-Compartment Septic Tank/Soil Absorption Field 5. Lagoon/Spray Irrigation (Slow Rate) System 6. Package Plant/Surface Water Discharge 7. Package Plant/Percolation Ponds 8. Package Plant/Rotary Distributor 9. Marsh-Pond/Surface Water Discharge 10. Oxidation Ditch/Surface Water Discharge	1. Land Application of Sludge/Septage 2. Sludge Landfilling-Area Fill 3. Sludge Storage 4. Sludge Landfilling-Trenching 5. Sludge/Septage Lagoon 6. Co-Incineration 7. Composting Sludge/Septage 8. Septage Treatment/Disposal 9. Conventional Landfill
Central/Regional*	1. Gravity Sewers 2. Force Mains	1. Lagoon/Spray Irrigation (Slow Rate) System 2. Physical/Biological Treatment Plant/Inland Surface Water Discharge 3. Physical/Biological Treatment Plant/Ocean Outfall	1. Land Application Sludge/Septage 2. Sludge Landfilling-Area Fill 3. Sludge Landfilling-Trenching 4. Sludge/Septage Lagoon 5. Co-Incineration 6. Composting 7. Conventional Sanitary Landfill

*Central/Regional Systems can also incorporate the collection alternatives proposed for the Community Systems for their collection/transport systems, when feasible.

Note: For direct discharge alternatives obtain effluent limits from the N.C. Department of Natural Resources and Community Development, Div. of Environmental Management.

Source: Gannett Fleming Corddry and Carpenter, Inc. 1981.

they should continue to offer satisfactory service. As Table II.1 indicates, many treatment and disposal options are available to respond to local conditions.

Some draft 201 Plans have cited existing on-site systems on barrier islands as sources of pollution of nearby surface and groundwaters and of health hazards after rainfalls. A few field monitoring and sampling programs have found this to be true in two isolated specific sites where they were installed in fill material on finger-fill canals. Otherwise, on-site systems are functioning well.

Conversion of existing conventional, on-site disposal fields (soil absorption beds and trenches) to alternative on-site systems resolve many of the problems stemming from excessively permeable sands and shallow soils with a high water table. In order to attain optimum operation of existing systems, a concerted effort must also be made to repair or upgrade septic tanks and possibly modify the soil absorption fields if insufficient renovation is occurring within the soil medium. Also, in areas where well contamination could be a threat to public health, renovation of on-site systems could decrease risks of water quality degradation.

(b) Community Systems

A community system serves a small cluster of usually ten to several hundred residences. It involves centralized collection in conjunction with treatment/disposal alternatives that do not differ significantly from individual systems, although a few more options become feasible. Small community systems can provide a wastewater management solution in an area of failing individual systems and preclude the need for connection to a central/regional system, if one is available. Small community systems may also be used for new development at densities greater than those supported by individual on-site systems or in areas not suited for individual on-site systems due to poor soils or seasonally high water tables. For these small systems, the cost of collection, especially by force mains and conventional gravity sewers, is often significant. Therefore, the alternatives identified for the collection system are a major cost factor of the whole system. With the larger flows from a collection system, flow equilization prior to treatment units, particularly package plants, should be utilized.

(c) Central/Regional Systems

These systems have comprised the traditional approach in 201 Plans to wastewater management and involve extensive collection systems leading to a centralized treatment facility. The main consideration is that a sufficient, relatively contiguous development be available to make this approach financially viable. To minimize collection costs for a large-scale system, the innovative collection alternatives used for community systems can be incorporated in the collection/transport system whenever possible for these regional systems.

(d) Combination of Systems

In many instances a community can be served most cost-effectively by a mixture of individual on-site, small community and central/regional facilities. Such an alternative should be developed and carried through the evaluation process.

(e) Sludge/Septage Handling and Disposal Systems

This has been considered an important factor in wastewater management system development for barrier islands and is a component of all alternative systems. Many of these disposal techniques are suitable for both septage and sludge disposal and have limited application based mainly on constraints due to state regulations, land area availability, and volume of sludge and/or septage generated by the treatment components in the various system alternatives. All sludge/septage disposal alternatives are generally centrally managed and operated, regardless of the type of wastewater treatment/disposal system utilized.

A detailed description of each alternative is provided in Appendix A, Details of Wastewater Management Options. Included in Appendix B, Wastewater Management System Selection Criteria, are lists of advantages, disadvantages, modifications and constraints for each alternative. Additionally, engineering design data for each of these systems is presented in Appendix C, Wastewater Treatment Alternatives Engineering Design Criteria.

(2) Procedures for Selecting Technically Feasible Components of Wastewater Management Systems

One of the more complex problems in assessing the wastewater management system requirements of an area or group of areas is that of determining what portion of that area's needs can be managed with on-site systems using soil absorption systems and what portion of the area's needs, if any, must be managed by use of some form of transport, treatment and disposal system. This analysis is detailed in Figure II.9.

Population should be distributed to the study area based on the use of on-site systems as consistent as possible with projected future land uses. The next step is to compare population figures and land uses resulting from this alternative with approved population projections and land uses. Areas of conflict should be identified and delineated on a map:

No Conflict:
Areas where population and development densities can be supported by on-site systems.

Conflict:
Areas where existing wastewater systems have documented problems.
Areas where development densities cannot be supported by on-site systems.
Areas not suitable for on-site systems due to soil limitations.

For areas where conflicts exist, consideration should be given to the following measures:

- Revise land uses and population figures
- Select community systems for higher density areas
- Select community systems for areas with unsuitable soils
- Select a central/regional system.

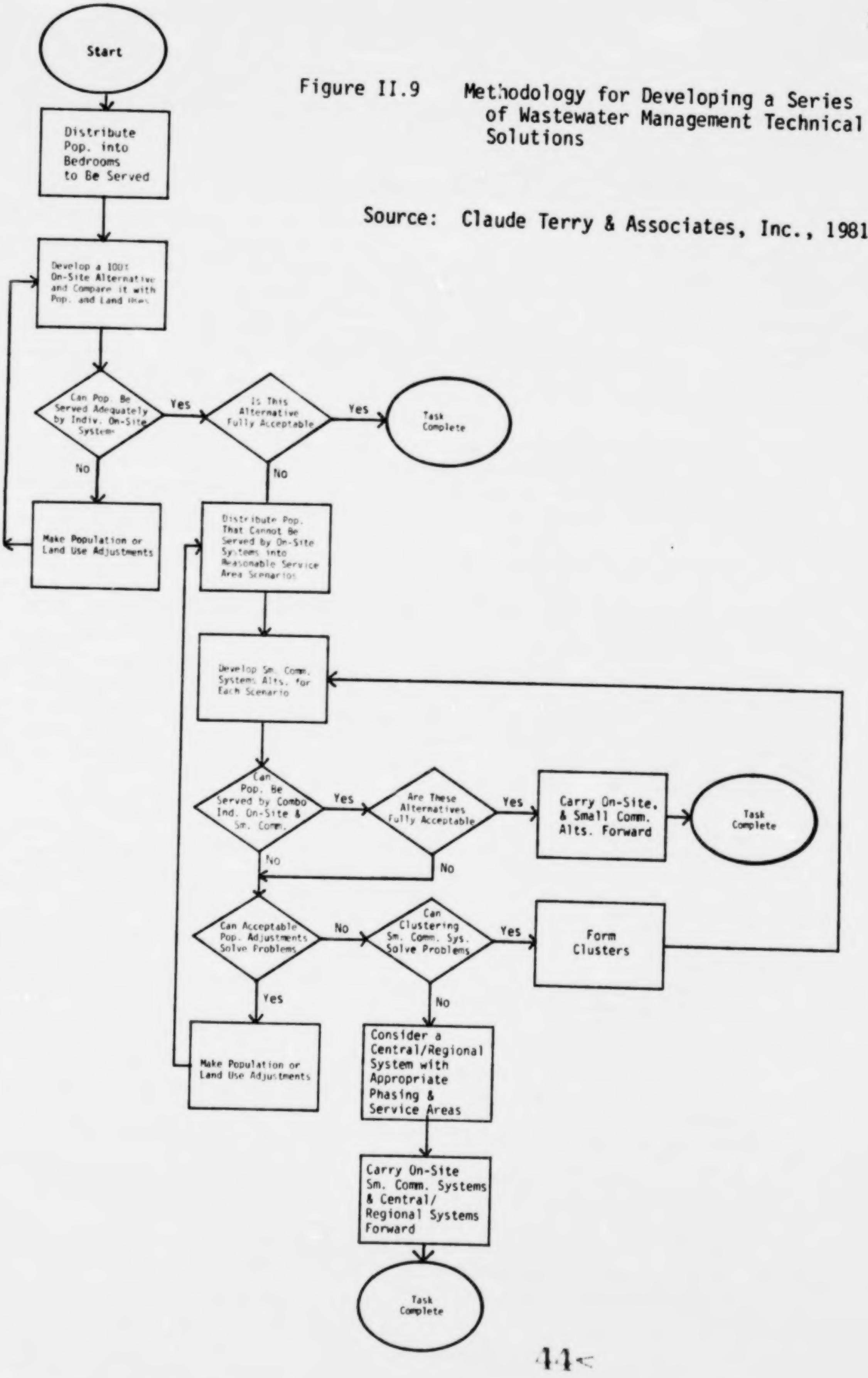

Start
Distribute Pop. into Bedrooms to Be Served
Develop a 100% On-Site Alternative and Compare it with Pop. and Land Uses
Can Pop. Be Served Adequately by Indiv. On-Site Systems
Yes
Is This Alternative Fully Acceptable
Yes
Task Complete
No
No
Make Population or Land Use Adjustments
Distribute Pop. That Cannot Be Served by On-Site Systems into Reasonable Service Area Scenarios
Develop Sm. Comm. Systems Alts. for Each Scenario
Can Pop. Be Served by Combo Ind. On-Site & Sm. Comm.
Yes
Are These Alternatives Fully Acceptable
Yes
Carry On-Site, & Small Comm. Alts. Forward
Task Complete
No
No
Can Acceptable Pop. Adjustments Solve Problems
No
Can Clustering Sm. Comm. Sys. Solve Problems
Yes
Form Clusters
Yes
No
Make Population or Land Use Adjustments
Consider a Central/Regional System with Appropriate Phasing & Service Areas
Carry On-Site Sm. Comm. Systems & Central/Regional Systems Forward
Task Complete

Figure II.9 Methodology for Developing a Series of Wastewater Management Technical Solutions

Source: Claude Terry & Associates, Inc., 1981

The first alternative for areas not suitable for on-site systems is to consider whether the projected population numbers are realistic and desirable. If not, population distributions can be revised, and the new projections can be checked to see if they now may be accommodated by on-site systems. If the new projections allow the population to be served, an assessment is made if the projection and resulting distribution are reasonable considering existing platting, zoning and known development interests. (Include environmental, socioeconomic and financial impacts in this determination of reasonableness.) If this adjustment is satisfactory, the need to publicly provide for off-site treatment may have been removed, and no further alternatives development may be necessary.

If the population and land use adjustments and on-site systems are not fully acceptable, several small community system alternatives should be developed. A minimum of two alternatives should be developed. One alternative, utilizing on-site systems to the maximum and small community systems to solve existing water quality problems, should be developed. A second alternative should also be developed utilizing on-site systems and small community systems for solving both existing water quality problems and accommodating future high density development or development projected on unsuitable soils. These alternatives should be carried into more detailed development and evaluation tasks along with the previously developed on-site alternative.

If the small community systems alternatives are not fully acceptable, consideration should be given to adjusting projected populations, and/or grouping of the small systems. If these developed alternatives do not meet all needs, consideration should then be given to central/regional systems.

The major factors in developing central/regional systems are alternative phasing of facilities and alternative groupings of major service areas. Intergovernmental agreements to accomplish economies of scale should be considered.

Consideration should be given to the impacts of the various discharge modes. Discharge to surface water bodies is frequently precluded on barrier islands, both because of the lack of suitable receiving streams and because of the potential negative environmental impacts of such discharges. State law allows no discharges to SA waters. Discharges may be permitted to SC waters where adequate assimilative capacity exists. Surface discharges to estuaries are similarly regarded, due to potential impacts on shellfish and other resources. Ocean outfalls are typically not cost effective for disposing small volumes of effluent and may have undesirable impacts on beach-side communities.

The typical discharge modes on barrier islands involve surface or subsurface disposal of effluent on the soil. Several factors regarding wastewater disposal into groundwater deserve consideration. These factors include:

- Potential for human recreational body contact with bacteria and viruses from wastewater
- Bacterial and nitrate contamination of drinking water supplies
- Overenrichment of the near surface waters with nutrients.

Typically, such negative impacts can be avoided by incorporating proper elements in system design. Design criteria which can eliminate or significantly minimize the above mentioned effects include:

- Spatial separation of disposal areas from surface waters
- Disinfection systems to alleviate potential for bacterial contamination
- Spatial separation of wastewater discharges from potable water supply wells
- Consideration of depth to water table and use of mounds or other appropriate on-site technologies
- Consideration of the potential uses for the groundwater in the area of discharge. If no future use for potable water supply is planned. different loading considerations may be applicable.

At this point several on-site, small community and/or regional treatment systems and land areas suitable for ultimate disposal are to be developed for further, more detailed evaluation. Several reasonable combinations of system elements may be structured which meet the volume and load requirements within the constraints of hydrology, soils, depth to water table, topography and public health considerations. These systems should be examined for consistency with statutory and socioeconomic requirements (i.e., are the system components legal in North Carolina, what impact does the system have on neighboring land uses, etc.). The feasible systems identified then receive further consideration in subsequent tasks. Technically and identified institutionally acceptable alternatives should be evaluated for cost effectiveness at the volumes and loads to be handled.

Determination of the small community systems appropriate for a given community is best done with input from local sanitarians, hydrologists or similarly trained persons with local on-site experience. Each barrier island area is to some extent unique in wastewater treatment needs, soil quality and quantity available for use in treatment and disposal, financial capability to fund part or all of the needed facility, and social and political structure. While the needs may differ, many examples now exist nationally of small communities adapting various technologies to conform to their specific needs.

At the conclusion of the technical development of alternatives, several of the options should be evaluated further (in subsequent tasks). An alternative employing on-site systems with small community systems used to solve existing water quality problems should always be developed and carried through subsequent tasks. If this system is fully acceptable, no further alternative development may be necessary. If not acceptable, an alternative comprised of on-site systems and small community systems to handle existing water quality problems and future high density areas is developed and always carried through the remaining development and evaluation tasks. If these alternatives are not fully acceptable, various central/regional alternatives should also be developed and carried through the detailed development and evaluation tasks.

(3) Procedures for Determining the Hydrodynamic Response to On-Site Disposal of Wastewater

When determining the applicability of on-island disposal systems to a given area, it is important to consider the response of the water table aquifer to disposal of wastewater. Wastewater disposal on barrier islands should be considered a net addition to total groundwater recharge if water is initially obtained from mainland sources. This net addition could result in physical contact between the water table and the bottom of drain field trenches or even surfacing of effluent. These groundwater-related problems can be identified by following a procedure illustrated on Figure II.10.

Fetter (1971) developed a procedure, based on the Ghyben-Herzberg principle (Fetter 1980), which allows estimation of changes in the water table hydrograph of a given cross-section of island. The application of Fetter's procedure applies to unconfined coastal aquifers where both fresh groundwater and saline groundwater are assumed to be static. This assumption does not introduce significant errors except in close proximity to the shoreline (see Figure II.11). At the shore edge, depth to the interface will be at a greater depth, and the elevation of the groundwater table above mean sea level will be slightly greater. For an island with groundwater flow only perpendicular to the shore line, the simplified equation takes the form

$$h^2 = \frac{w(a^2 - (a - x)^2)}{k\ (41)}$$

h = water table elevation above mean sea level (ft)
w = average aquifer recharge (ft/day)
2a = island width (ft)
x = distance from the shoreline (ft)
k = hydraulic conductivity of the water table aquifer (ft/day)

Figure II.11 is a graphic representation of h, a and x. Aquifer recharge and hydraulic conductivity must be determined from published information or field studies. If more than one aquifer exists above the freshwater-saltwater interface, k will equal the average hydraulic conductivity of existing aquifers. The assumptions of the equation are listed below:

- The freshwater-saltwater interface is very narrow.
- Hydraulic conductivity is constant across the island width.
- Groundwater flow is horizonal and only occurs perpendicular to the shore line.
- Wastewater loading is constant over time and space.
- Rainfall is at a constant rate over time and uniform over the island.
- Tidal influences near the coast are insignificant.

At the coastline, tidal influences may be significant. Septic tank soil absorption systems, however, are not usually built within 40 feet of the coastline. It is within this distance where tidal influences are most apparent; the influence is insignificant 50 feet and further from the coastline.

The influence of temporal variations in precipitation, wastewater disposal and groundwater storage is also not significant; mean daily recharge gives a close estimate of the water table elevation. A four-inch rainfall occurring in one day causes a long term increase in the water table elevation above mean sea level of one third of one inch (based on a porosity of 0.33). One example of the short term reaction due to a four inch storm event is shown in Appendix D, Table D.3. The water table (at any point where aquifer thickness = 200 ft) moves essentially back to pre-storm equilibrium in four days; 76 percent of the increase in storage is lost after one day. The

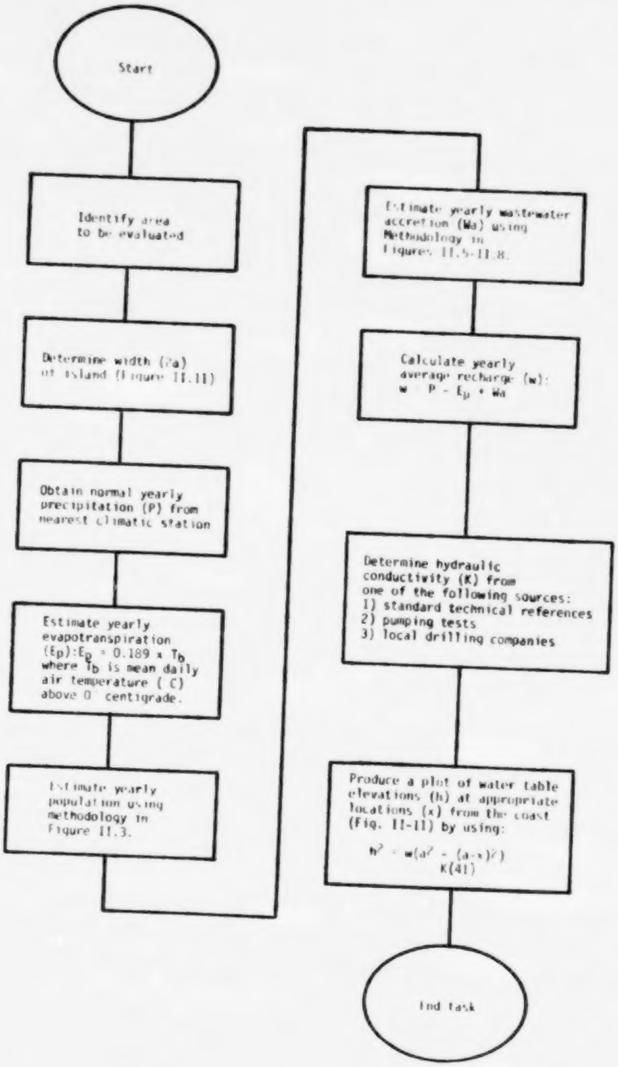

Start
Identify area to be evaluated
Determine width (2a) of island (Figure II.11)
Obtain normal yearly precipitation (P) from nearest climatic station
Estimate yearly evapotranspiration (E_p): $E_p = 0.189 \times T_b$ where T_b is mean daily air temperature (C) above 0° centigrade.
Estimate yearly population using methodology in Figure II.3.
Estimate yearly wastewater accretion (Wa) using Methodology in Figures II.5-II.8.
Calculate yearly average recharge (w): $w = P - E_p + Wa$
Determine hydraulic conductivity (K) from one of the following sources:
1) standard technical references
2) pumping tests
3) local drilling companies
Produce a plot of water table elevations (h) at appropriate locations (x) from the coast (Fig. II-11) by using:
$h^2 = \frac{w(a^2 - (a-x)^2)}{K(41)}$
End task

Figure II.10 Methodology for Determining Water Table Elevation above Mean Sea Level for an Infinite-Strip Island

Source: Claude Terry & Associates, Inc. 1982.

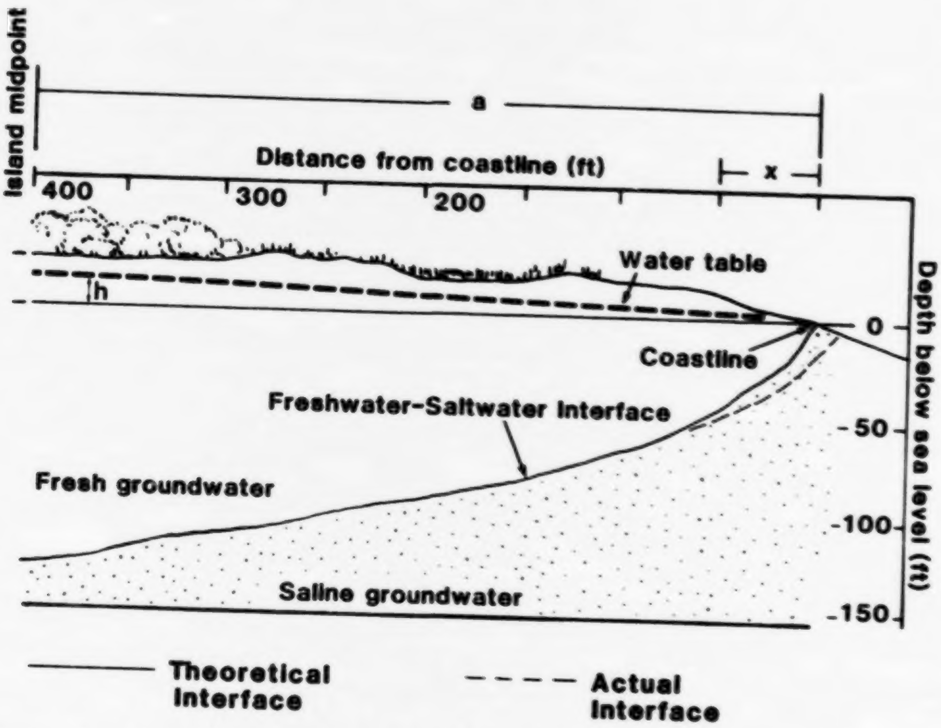

Island midpoint
a
Distance from coastline (ft)
x
400
300
200
h
Water table
0
Coastline
Freshwater-Saltwater Interface
- 50
Fresh groundwater
-100
Saline groundwater
-150
Depth below sea level (ft)
Theoretical Interface
Actual Interface

Figure II.11 Identification of Water Table Elevation (h), Island Width (2a) and Distance from Coastline (x) Used in the Prediction Equation

Source: Fetter, C.W., Applied Hydrogeology. 1980.

additional recharge to the water table aquifer resulting from a four-inch rainfall stays in storage for at least several months. However, this carry-over effect in storage is insignificant because only about 1/40 of the additional storage adds to the total height of the water table. Appendix D discusses these responses in greater detail.

Spatial variations in hydraulic conductivity can influence the results obtained when using the procedure described in this section. A 100 percent increase in hydraulic conductivity will result in a 30 percent decrease in water table elevation. Field studies would be appropriate where groundwater levels are close to the surface and no actual values for hydraulic conductivity are available.

Actual mounding of the water table and subsequent surfacing of effluent may occur where several septic systems are close together. Where mounding is likely, more detailed studies should be incorporated. The North Carolina Department of Natural Resources and Community Development, Office of Water Resources is presently refining a method, based on well drawdown, that estimates effluent mounding around rotary distributors (Shiver 1983). Fetter (1972) also developed a numerical solution that describes the hydrodynamic response of the water table to wastewater disposal on barrier islands. The DNRCD solution differs from Fetter's equation because the amount of recharge can be varied spatially across the island to reflect the distribution of wastewater recharge and mounding usually concomitant with densely placed septic tank systems.

(a) Aquifer Recharge

Recharge of the water table aquifer on barrier islands is mostly by rainfall; direct runoff is usually insignificant. Thus, recharge can be computed using the following balance equation:

Recharge = Precipitation - Evapotranspiration + Wastewater

Monthly and yearly values of normal precipitation for the barrier island region can be obtained from local weather stations. Techniques used to measure evapotranspiration are based on four general approaches: water budgeting, energy budgeting, vapor flow and empirical methods. The most common approach used to estimate evapotranspiration is through empirical models. Yearly evapotranspiration (Ep) can be computed using the following equation:

$$Ep = 0.189 \times T_b$$

T_b = mean daily air temperature (°C) above 0° Centigrade.

Wastewater flows are based on population estimates. Average monthly flow can be determined using the methodology presented in Figures II.5-II.8.

(b) Hydraulic Conductivity

The hydraulic characteristic of the aquifer materials is expressed as the conductivity, a measure of the rate at which the aquifer can transmit a fluid. The hydraulic conductivity of an aquifer is usually determined from aquifer tests made on wells that penetrate the aquifer. Prickett (1965) presented a graphic method for the solution of hydraulic conductivity from aquifer tests in an unconfined aquifer. These tests indicate that most barrier islands have hydraulic conductivities that range from 25 ft/day to 200 ft/day; 50 ft/day would be a conservative value in water table calculations. Information regarding actual hydraulic conductivities might be obtained from local drilling companies or from standard reference sources.

(c) Model Results

Figure II.12 depicts three hydrogeological situations that can be predetermined by using the procedure outlined in this section. Point A on the figure represents a location where effluent might accumulate above ground. Point B represents a location that would only be suitable for construction of a septic system under existing occupancy because the predicted elevation of the water table under maximum occupancy intersects the lower boundary of the drainfield trench. Point C represents an area where groundwater seepage might occur under maximum occupancy. If a septic system is constructed adjacent to and above point C, effluent from the system might seep from the outflow face. Appendix D contains a hypothetical case study where detailed calculations have been made and conclusions drawn based on the position of the water table under existing and maximum occupancy.

The analytical solution presented in this section describes the hydrodynamic response of the water table to land disposal of wastewater in an idealized representation of actual aquifer configurations. In actuality, aquifers are not homogeneous nor is the permeability of the unit the same in all directions. Existing aquifers on barrier islands are created by complex geologic processes that in certain cases may have led to irregular stratigraphy of confined and unconfined aquifers. The prediction that can be carried out with the expression presented in this section is a best estimate; this estimate approaches more closely the actual hydrogeological environment as the actual conditions approach the idealized configuration.

(4) Procedures for Estimating Collection System Costs

Cost estimates for collection systems should be done in stages. Alternative or innovative collection systems should be considered when they can be shown to be cost-effective. The size and cost of each component must be developed. Unit cost information should be developed from manufacturer's data where possible. Construction costs can be developed from EPA information or local contractors.

(5) Procedures to Identify Special Costs Incurred on Barrier Islands

Since the soil characteristics in many areas are not suitable for the foundations of treatment facility structures, the additional cost of pilings or other special foundations has to be considered. Additionally, structures have to be built to withstand the effects of weathering including high winds, sea spray corrosion and sand abrasion. These parameters affect both the initial construction costs of any wastewater management system and the long term operation and maintenance costs of the system.

The investigator should determine if increased initial costs for heavy duty coatings, more ruggedly constructed treatment equipment or the use of stainless steel in place of other less corrosive and erosive metals can be justified over the life of the facility due to decreased operation and maintenance costs of more weather resistant facilities.

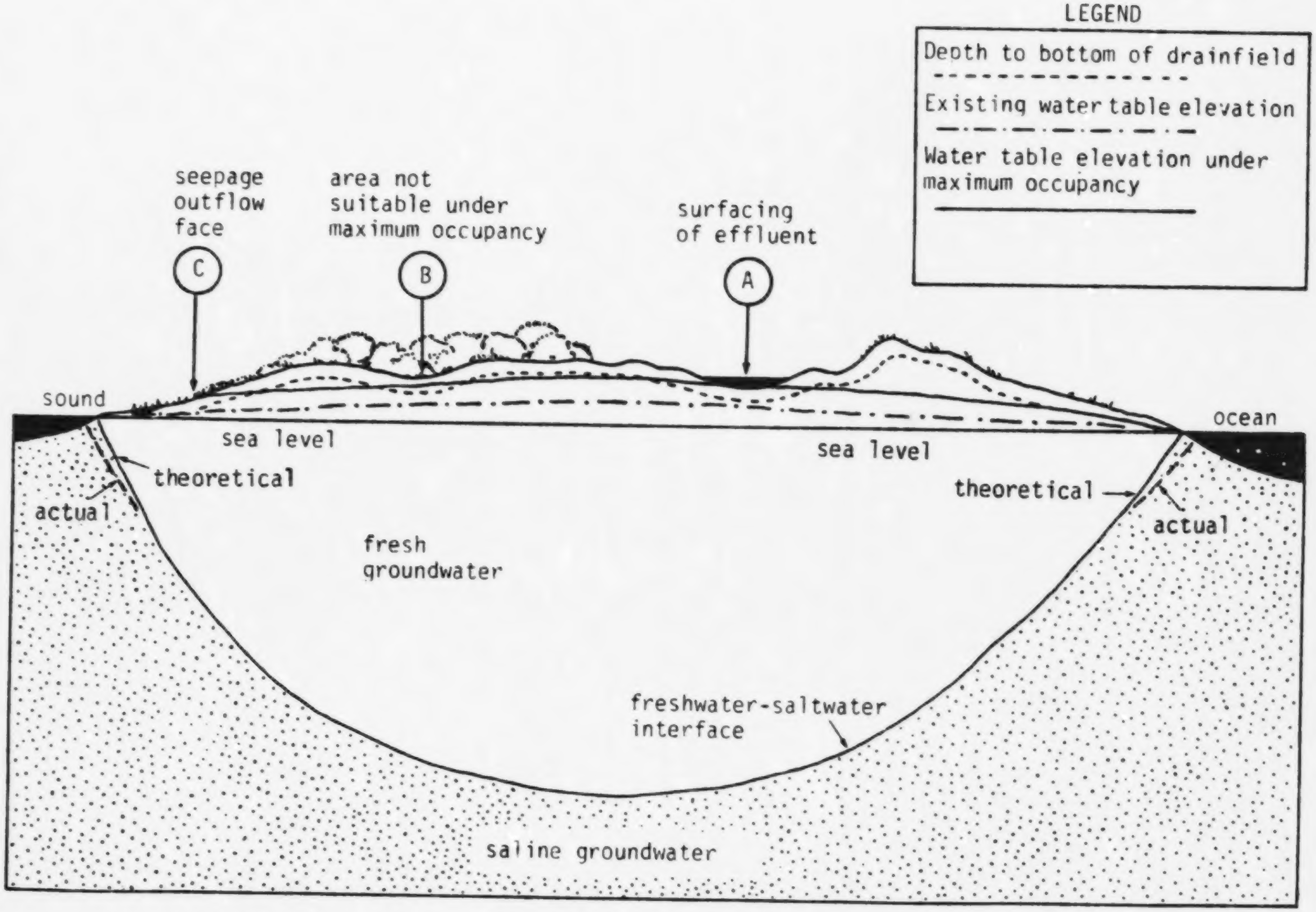

LEGEND
Depth to bottom of drainfield
Existing water table elevation
Water table elevation under maximum occupancy
seepage outflow face
C
area not suitable under maximum occupancy
B
surfacing of effluent
A
sound
ocean
sea level
sea level
theoretical
actual
theoretical
actual
fresh groundwater
freshwater-saltwater interface
saline groundwater

Figure II.12. Possible Hydrogeological Situations That Can Be Identified

Source: Claude Terry & Associates, Inc. 1982

Sand and salt spray have a detrimental effect on the serviceability of structures and equipment. Facilities constructed on the barrier islands must be recoated or painted more often, bearings have to be repacked more often and wear of all moving parts is increased due to the sand and corrosion problems. Quantifying the additional costs associated with these problems necessitates studying manufacturers' coatings data to determine the expected lives of their coatings, determining the effects that the weather and sand will have on the designed bearing life of critical equipment and evaluating the effects that the corrosive atmosphere will have on electrical equipment.

(6) Procedures for Developing Institutional Management Alternatives

The implementability of a technical wastewater management alternative requires consideration of the legal and institutional requirements of each alternative system previously developed. State enabling legislation provides a far wider range of powers and authority to cities than are granted to unincorporated communities. The ability of a management agency to own real property, enter into contracts, set rates, receive grants, employ personnel, etc. are critical aspects of implementability.

Institutional considerations were not fully analyzed in most of the draft 201 Plans. Therefore, the EIS developed a series of worksheets and other analytic tools to aid grant applicants in defining their institutional and financial constraints and developing optimum management alternatives. These tools were presented in a series of workshops during December 1981 and January 1982.

Institutional considerations focus on what management agencies may receive 201 funds and administer wastewater management facilities. Where wastewater management is already a community service, an analysis of the effectiveness of the present management structure is the point of departure in determining whether existing institutional arrangements can be expected to adequately manage a new or upgraded system or whether a new mechanism needs to be devised.

Where wastewater management represents a new service, options must be explored as to whether the community should:

- Serve only itself
- Incorporate adjacent neighborhoods into its service area through its powers of extra-territorial jurisdiction
- Be served by a larger jurisdiction such as the county
- Make overtures to join another jurisdiction in a cooperative venture.

North Carolina law provides possibilities for a large number of institutional management options:

- A city utility or public works department
- A county utility or public works department
- A joint management agency
- A county service district
- A sanitary district
- A water and sewer authority
- A metropolitan water district
- A metropolitan sewerage district
- A private water and sewerage company.

Two or more communities may sign an interlocal agreement whereby one of the parties provides services to all the communities. In a given 201 planning area, it is possible for more than one of the above agencies to be providing services.

Figure II.13 presents a simplified methodology for selecting one or more feasible institutional management alternatives. The user should step through the methodology once for each technical alternative developed, consulting Table II.2 where appropriate. This discussion is supplemented by an EIS task report, Implementing Wastewater Facilities Plans in the Barrier Island Region of North Carolina: Institutional and Financial Issues and Needs (Briscoe, Maphis, Murray & Lamont, Inc. 1981).

(7) Procedures for Developing Financial Management Alternatives

The steps a community should follow in reaching a decision about the affordability of each of the technical solutions previously documented have been developed into a series of procedures. The issue of affordability focuses on the ability of the community both to raise capital and to meet operating costs.

The development of financial management alternatives is a particularly important task since barrier island communities are characterized by highly fluctuating seasonal flows. The issue of user fees requires detailed examination. Several options are available to accommodate the incremental costs of providing capacity for seasonal users:

- Peak month(s) surcharge for all seasonal users
- Seasonal differential based on type consumer
- Seasonal differential based on type technology used.

The analysis begins by assessing the present financial status of the community. Whether or not a community decides to serve itself, it should explore the alternative of cost-sharing schemes. Figure II.14 is a systems flowchart describing these analyses.

Before a community can consider assuming additional long term debt or operating costs of a wastewater management system, it must first assess its present financial condition. An understanding of the existing resource base, current practices and committments, and fiscal capacity of the local government is essential.

(a) Bonding Capacity and Sources of Operating Income

The first step is to delineate the bonding capacity of the local government. Bonds may only be used to defray capital expenditures, not operating costs. By state law, local governments' total bonding capacity is set at eight percent of the total assessed property tax base. Both general obligation bonds and lease-purchase agreements are subject to the eight percent ceiling although revenue bonds are not. The only exception to this provision is that when the North Carolina Environmental Management Commission or a court requires the implementation of wastewater treatment systems, general obligation bond debt is not subject to the eight percent net debt limit.

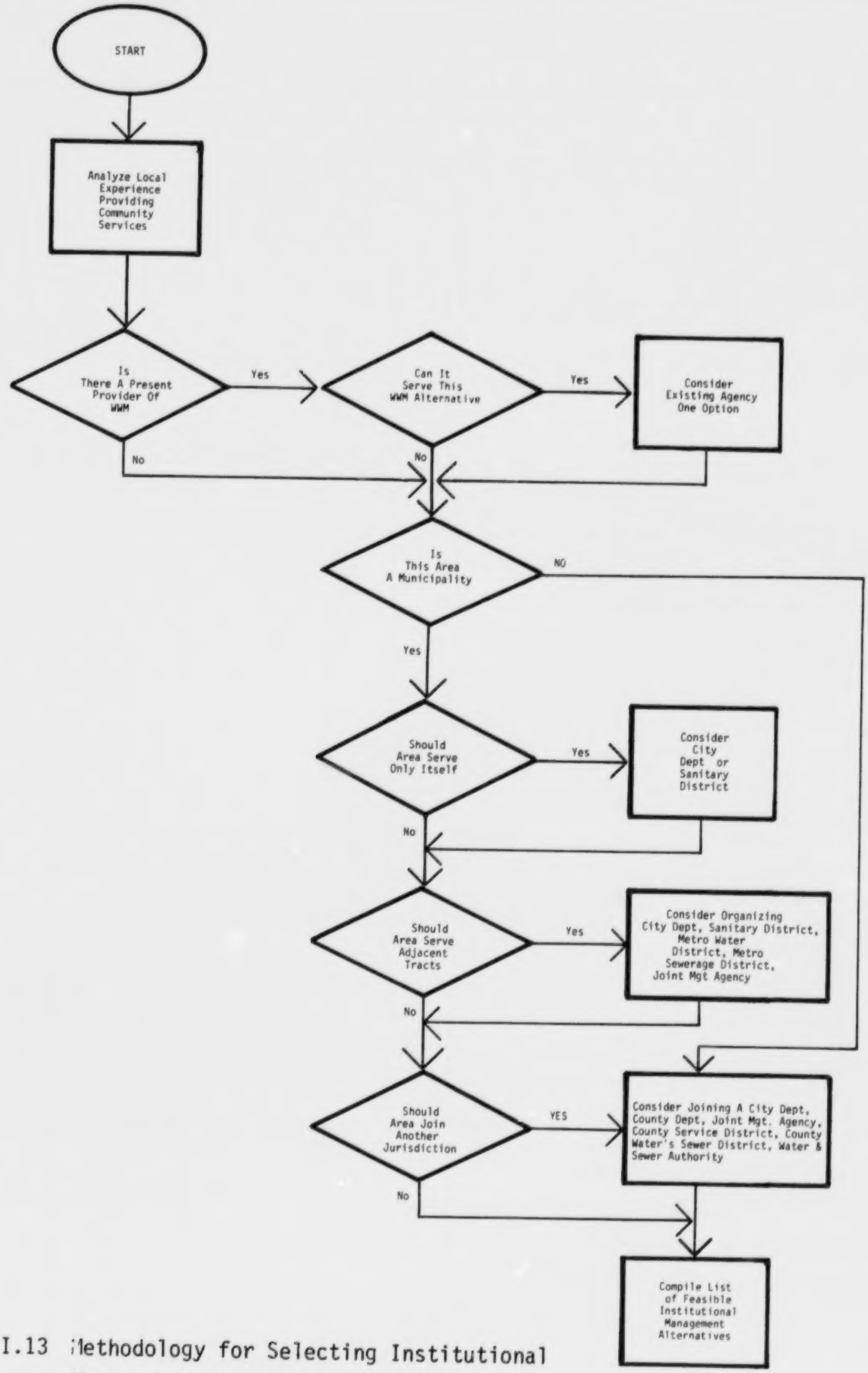

START
Analyze Local Experience Providing Community Services
Is There A Present Provider Of WWM
Yes
Can It Serve This WWM Alternative
Yes
Consider Existing Agency One Option
No
No
Is This Area A Municipality
NO
Yes
Should Area Serve Only Itself
Yes
Consider City Dept or Sanitary District
No
Should Area Serve Adjacent Tracts
Yes
Consider Organizing City Dept, Sanitary District, Metro Water District, Metro Sewerage District, Joint Mgt Agency
No
Should Area Join Another Jurisdiction
YES
Consider Joining A City Dept, County Dept, Joint Mgt. Agency, County Service District, County Water's Sewer District, Water & Sewer Authority
No
Compile List of Feasible Institutional Management Alternatives

Figure II.13 Methodology for Selecting Institutional Management Alternatives for Each Technical Alternative

Source: Claude Terry & Associates, Inc. 1981.

Table II.2

Capabilities of Institutional Management Alternatives CAPABILITIES / SERVICE PROVIDER	City Department	County Department	Joint Mgmt. Agency	County Service District	County Water & Sewer District	Sanitary District	Water & Sewer Authority	Metro Water District	Metro Sewerage District	Private Corporation
Service Area:										
1. Can serve more than one polit. jurisdiction within a county?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Can serve less than a whole county?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Can serve more than one county?	Y	Y	Y	N	N	Y	Y	N	Y	Y
Service area boundaries can be expanded?	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
Finance: Raise Funds										
2. Can issue general obligation bonds?	Y	Y	N	Y	Y	Y	N	Y	Y	N
Can issue revenue bonds?	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
Can impose assessments?	Y	Y	N	Y	Y	N	Y	N	N	N
Can levy property taxes?	Y	Y	N	Y	Y	Y	N	Y	Y	N
Can set fees, rates, charges?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Finance: Receive Funds										
3. Can directly receive local option tax funds?	Y	Y	N	N	N	N	N	N	Y	N
Can directly receive HUD Community Development Block Grant funds?	Y	Y	N	N	N	N	N	N	N	N
Holds title to all real property of system?	YorN	YorN	N	YorN	YorN	YorN	YorN	YorN	YorN	Y
Can directly receive federal revenue sharing funds?	Y	Y	N	N	N	N	N	N	N	N
Voter Responsiveness:										
4. Service users have direct control of service providers via ballot box?	Some	Y	N	Y	Y	Y	N	N	N	N
It is a unit of government?	Y	Y	N	N	Y	Y	Y	Y	Y	N
5. Single purpose agency?	N	N	YorN	N	N	N	N	N	Y	Y

Source: Compiled by Claude Terry & Associates, Inc., Atlanta, GA from the text of: University of North Carolina Water Resources Research Institute. 1980. Wastewater Management in Coastal North Carolina. Chapter IV.

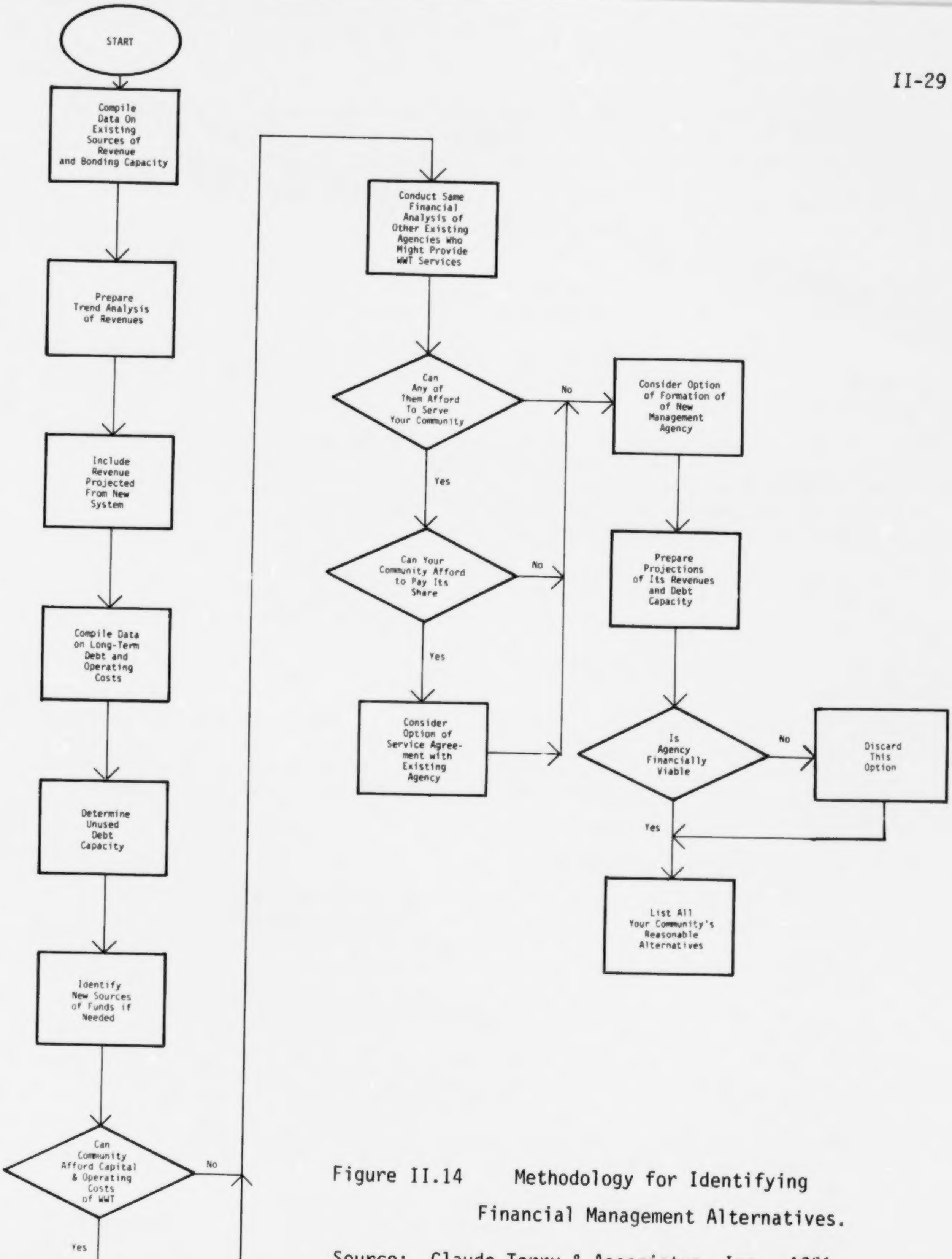

START
Compile Data On Existing Sources of Revenue and Bonding Capacity
Prepare Trend Analysis of Revenues
Include Revenue Projected From New System
Compile Data on Long-Term Debt and Operating Costs
Determine Unused Debt Capacity
Identify New Sources of Funds if Needed
Can Community Afford Capital & Operating Costs of WWT
No
Yes
Consider Option of Providing Own Services
Conduct Same Financial Analysis of Other Existing Agencies Who Might Provide WWT Services
Can Any of Them Afford To Serve Your Community
No
Yes
Can Your Community Afford to Pay Its Share
No
Yes
Consider Option of Service Agreement with Existing Agency
Consider Option of Formation of of New Management Agency
Prepare Projections of Its Revenues and Debt Capacity
Is Agency Financially Viable
No
Discard This Option
Yes
List All Your Community's Reasonable Alternatives

Figure II.14 Methodology for Identifying Financial Management Alternatives.

Source: Claude Terry & Associates, Inc. 1981.

The next step is to compile data about existing sources of revenue which may legally be used to operate wastewater management systems. In North Carolina, these sources of income could include:

- Ad valorem (property) tax
- Local sales and use tax
- Business (privilege) license tax
- Local franchise tax
- Alcoholic Beverage Control tax
- User charges of existing wastewater treatment system, if any.

A trend analysis of revenue sources should be prepared by individual source to identify which sources can be expected to increase or decrease, particularly in response to inflation.

Proposed tap-on fees and user charges should be reviewed to evaluate their economic and political acceptability. EPA regulations (PRM 79-8) require that the following total annual costs to users should not exceed percentages of median family income and at the minimum must recover the costs of operation and maintenance and replacement:

1.00 percent when median family income is under $10,000
1.50 percent when median family income is $10,000-$17,000
1.75 percent when median family income exceeds $17,000.

If these guidelines are exceeded, special evaluations and procedures are necessary.

The affordability criteria should be applied only to the permanent residential population components and should not include the seasonal components. If necessary, more realistic fees and charges should be developed. Thereafter, the income from proposed user fees should be computed and added to other sources of revenue.

(b) Long Term Debt and Operating Costs

Projected operating costs should also be reviewed and compared against anticipated system revenues. If a deficit results, other sources of revenues which could serve to make up any differences between proposed user charges for the new system and actual costs should be evaluated.

Figures should also be compiled identifying the community's outstanding long term debt. Thereafter, an analysis of unused debt capacity should be made. If the community's bonding capacity is not large enough to accomodate a wastewater management general obligation bond issue, then the community's options include:

- Reducing the size of the bond issue by increasing tap-on fees
  Reassessing the property tax base to determine if the debt ceiling can be raised
- Considering the use of revenue bonds
- Exceeding the ceiling if implementation of the project is required by the North Carolina Environmental Management Commission or courts
- Considering other user charge systems.

(c) Identification of Additional Sources of Funds

If a shortfall is identified in either operating funds or the ability to finance capital costs, then new sources of funds need to be found. A shortfall in operating income generally results when the proposed user charges must be reduced and when subsidies from other revenue sources are not enough to make up the difference.

(d) Assessment of Existing Fiscal Capability

Public hearings should be held to present the findings of the financial analysis to system users and gather their comments. At a minimum, all property owners, both permanent and seasonal residents, should be notified by mail of the public meeting and anticipated financial impacts.

Thereafter, local officials can decide whether or not the community can afford the capital and operating costs of providing wastewater management systems. If the decision is negative, then community leaders should immediately investigate the costs of entering into a service agreement with an existing agency or new agency. Even if the community can afford to serve itself, the analysis of other financial management alternatives should proceed to the investigation of all reasonable alternatives.

Additional financial issues which need to be examined include:

- plans if outside funding sources are not available
- Sensitivity analysis which measures the degree of uncertainty attached to assumptions about the financial implications of population projections, flow volumes over time, inflation, energy costs, costs of goods and services, etc.
- Refinements to the local taxation system so that system beneficiaries more directly bear the costs. Examples include the issues 1) should tourists be paying a larger share than they do presently and 2) the assurance that new growth pays its fair share.

Although this discussion might seem to focus on the development of financial management alternatives for central or regional treatment plants, the development of financial management alternatives for small community systems should not be overlooked. Since both the costs and the benefits are likely localized, either direct assessments or assessment bonds provide the most reasonable financing mechanism in situations where wastewater management systems in areas of existing development need upgrading or replacing. In areas of future development where small community systems or individual on-site systems are appropriate, construction costs are routinely borne by the developer or individual homeowner.

Additional discussions about financial considerations can be found in a separately bound EIS task report, implementing Wastewater Facilities Plans in the Barrier Islands Region of North Carolina: Institutional and Financial Issues and Needs (Briscoe, Maphis, Murray & Lamont, Inc. 1981).

(8) Procedures for Developing Total Wastewater Management Systems Alternatives

Figure II.15 graphically depicts the evolutionary process that developing reasonable wastewater management systems appropriate for a given area requires. This task is begun by assessing all appropriate technologies applicable to any given service area and then to all groups of areas that reasonably can be considered together. Initially the development of logical service areas is a process of grouping subareas that a common technology such as septic tanks and soil absorption systems will handle. The objective of this process is to develop the reasonable technically feasible wastewater management systems that can handle the requirements of each service area. Figure II.16 illustrates this process.

Having generated a list of feasible technologies appropriate for the area, operational and financial management schemes then should be developed for each of the feasible technologies. The operational management scheme for each technology will have to consider the political jurisdictions involved, the ownership of the properties and treatment facilities involved, legal or statutory restraints and how the particular technology will be financed.

c. Procedures for Evaluating Alternative Wastewater Management Systems

Several alternatives will have been developed, each with a technical, institutional and financial component. The next step, therefore, is to evaluate each alternative with regard to those criteria upon which system selection depends:

- Cost and local financial impacts
- Primary and secondary environmental impacts
- Implementability.

the evaluation of each criteria within each alternative is conducted in two phases. The first phase involves the documentation of impacts. The second phase addresses the significance of the impact. Numerous techniques exist for evaluating significance. Some are very complex and subject to considerable manipulation. Other methods are very simple and consist of displaying impacts in tabular form.

(1) Cost and Local Financial Impacts

Barrier island communities tend to have relatively modest tax bases and permanent residents are sensitive to the costs of wastewater management systems. Procedures for evaluating costs are documented extensively in various EPA publications.

A detailed evaluation of all cost components in each of the alternative wastewater management systems is required in order to perform the comparative cost analyses. Land, construction, project (engineering, financing, and contingencies), salvage value, and operation and maintenance costs are developed for each management system for incorporation into a net present worth cost analysis. The present worth cost analysis establishes a basis for comparison of total costs (capital and annual operations costs) for each of the wastewater management alternatives. These total costs include the federal share

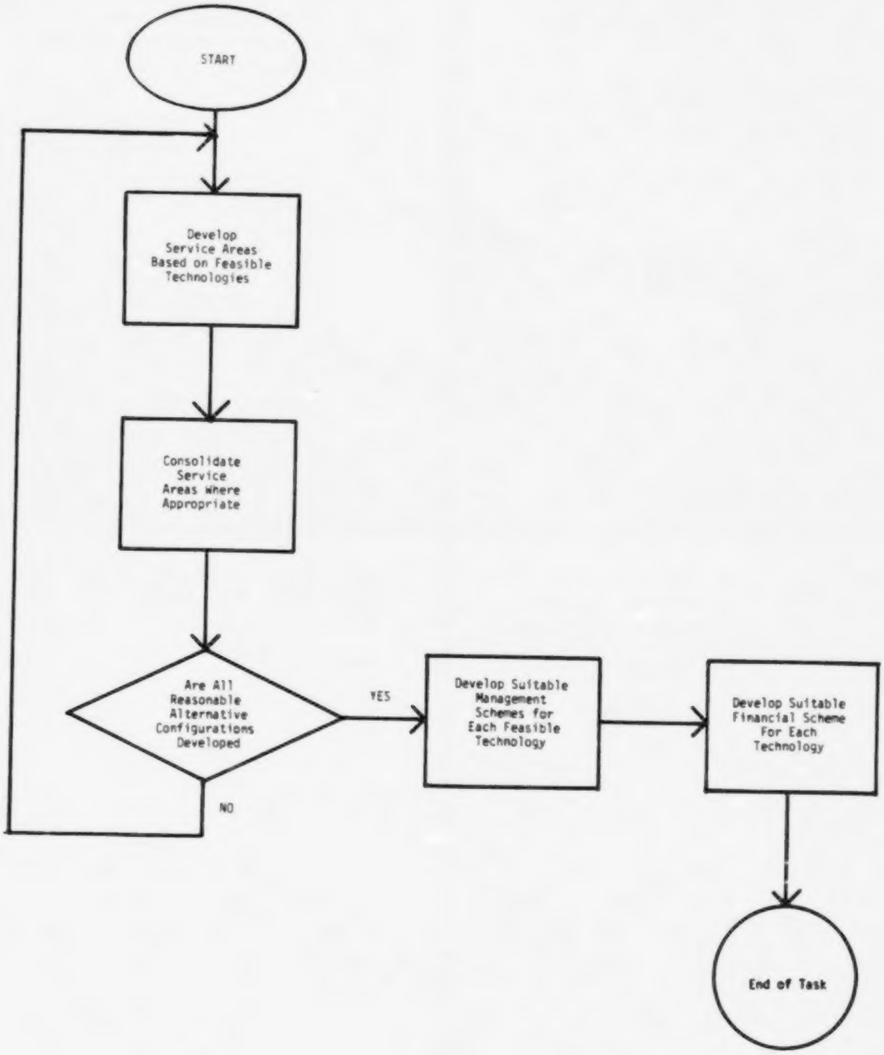
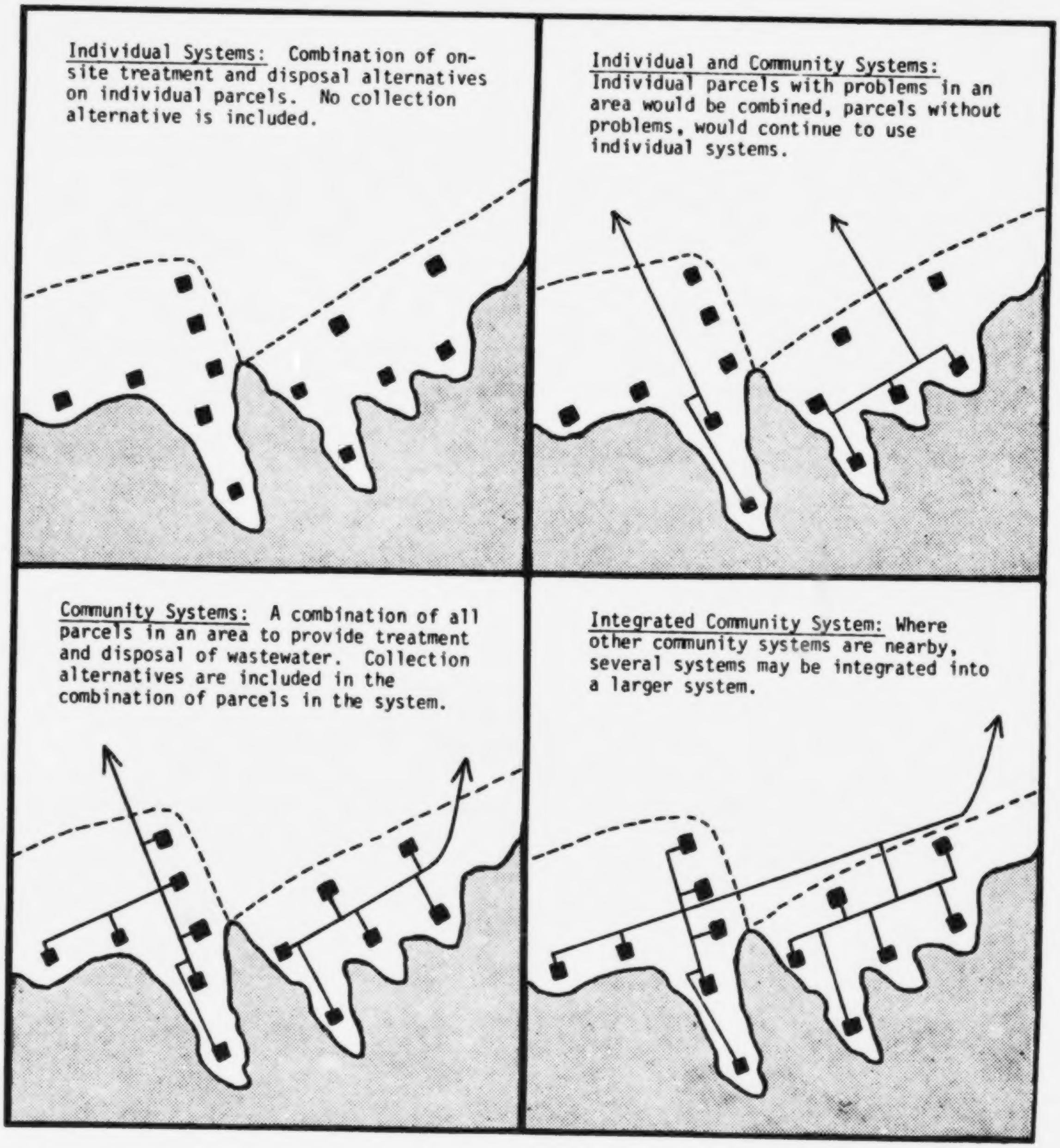

START
Develop Service Areas Based on Feasible Technologies
Consolidate Service Areas Where Appropriate
Are All Reasonable Alternative Configurations Developed
YES
NO
Develop Suitable Management Schemes for Each Feasible Technology
Develop Suitable Financial Scheme For Each Technology
End of Task

Figure II.15 Methodology for Developing Total Wastewater Management System Alternatives

Source: Claude Terry & Associates, Inc. 1981

Figure II.16 Conceptual Representation of Community Wastewater System Alternative Possibilities.



Individual Systems: Combination of on-site treatment and disposal alternatives on individual parcels. No collection alternative is included.

Individual and Community Systems: Individual parcels with problems in an area would be combined, parcels without problems, would continue to use individual systems.

Community Systems: A combination of all parcels in an area to provide treatment and disposal of wastewater. Collection alternatives are included in the combination of parcels in the system.

Integrated Community System: Where other community systems are nearby, several systems may be integrated into a larger system.

Note: Combined flows go to community, central or regional treatment system.

SOURCE: Adapted from "EPA Final Environmental Impact Statement Buckingham, Pennsylvania Wastewater Treatment Facilities" August 1981.

of the costs associated with construction grants. Comparative cost analysis (either present worth or equivalent annual cost) is an EPA requirement and serves as the primary cost evaluation criterion according to EPA guidelines.

The value of using present worth analysis is that the total costs of each alternative are related to each other during the 20-year planning period. Present worth analysis brings each total cost back to an equivalent investment cost as the beginning of the planning period, given a fixed interest rate on the investment. Thus, alternatives with high construction costs and low O&M costs can be equitably compared against alternatives with low construction costs and high O&M costs.

A present worth analysis requires that both public and private costs directly related to a project be included. Cost for laterals and ineligible rehabilitation of private on-site facilities are examples of private costs that should be estimated and included in present worth calculations. Although present worth analysis does not recognize the difference between public and private costs, it is necessary for local cost estimation.

The EIS has developed additional procedures, however, which respond to the financial profile of barrier island communities. The EIS found that significantly different financial impacts can be experienced at the local level, given several wastewater management alternatives. Much depends upon the degree to which costs are internalized or externalized. The selection of systems eligible for state or federal grants externalize many costs. Requiring tourists to pay their share of systems costs externalizes a large portion of what would otherwise be a local burden. Dependence on the ability to externalize costs can be dangerous for a community; provision must be made for the eventuality that state or federal funds may not be forthcoming.

(a) Risk Analysis

Evaluation of financial impact is a matter of both the size of the financial committment involved relative to the community resource base as well as the financial risk involved in the undertaking. Risk assessment is often overlooked, particularly a systematic identification of downside risk. Risk analysis should seek to pinpoint areas of uncertainty, and various types of sensitivity analysis described below are important tasks in the overall evaluation of financial impacts to local communities. Therefore, an initial task in screening all wastewater management alternatives should be the identification of what percent of life cycle total costs are capital costs (relatively firm, up front dollars) and what percent are operating costs (annual projections over 20 years).

The financial impacts of both the capital costs and operating costs of each alternative must be assessed. Table II.3 is a questionnaire which should be filled out for each alternative. The following discussion elaborates upon the questions raised in Table II.3.

Capital Cost Evaluation

1. How close to the net eight percent ceiling does each alternative bring the community's total bonded indebtedness? However, when bonds are

Table II.3. Local Financial Impacts Worksheet

Question

I. How close is the community to the net 8 percent ceiling if this alternative is implemented?

  a. No impact on indebtedness or more than 11% margin remaining after adding on new debt

  b. Within 0-5% of margin

  c. Within 6-10% of margin

  d. Over ceiling with state permission

II. For how many years will the city be at its debt capacity?

  a. No impact on indebtedness or not at ceiling

  b. 1-2 years

  c. 3 years or more

III. What other capital improvement opportunities are foregone and how urgent are they?

Name of Improvement	Priority

IV. Will issuing of wastewater management bonds reduce attractiveness of other local bond issues?

V. If project revenue shortfall occurs, what will be the impact of debt service demands on property taxes and user fees?

  a. Negligible

  b. Moderate

  c. Severe

VI. How sensitive is this alternative to the projected numbers of dwelling units not actually being built?

  a. Negligible

  b. Moderate

  c. Severe

Table II.3. Continued

VII. If an operating revenue shortfall occurs, how available are other sources to cover the deficit?

- a. Readily available
- b. Moderately available
- c. Limited

VIII. How sensitive are operating costs to

- a. Projected flow volumes
  - 1. Negligible
  - 2. Moderate
  - 3. High
- b. Inflation
  - 1. Negligible
  - 2. Moderate
  - 3. High
- c. Energy cost and availability
  - 1. Negligible
  - 2. Moderate
  - 3. High
- d. Scarce raw materials
  - 1. Negligible
  - 2. Moderate
  - 3. High

Source: Claude Terry & Associates, Inc. 1981.

issued by the county, an authority or a district, the city's bonded indebtedness is not affected.

2. If the city issues bonds, for how many years (if at all) will the debt capacity be at its ceiling?

3. By issuing wastewater management bonds, what other capital improvements opportunities are foregone? Parks? Public safety department plant and equipment? Commercial district revitalization?

4. How urgent are the city's other capital needs?

5. Will the issuing of wastewater management bonds reduce the attractiveness of bonds issued by other local jurisdictions, such as the Board of Education, etc.?

6. If project revenues cannot meet annual debt service needs, what will be the increase to property taxes and/or user charges? For some alternatives, the amount necessary to make up the shortfall may prove economically or politically unacceptable.

7. What will be the financial impact if the projected numbers of dwelling units are not built? How sensitive is the alternative to a smaller than projected amount of tap-on fees? This question applies to central and regional systems since on-lot systems do not involve tap-on fees and a reduction in number of dwelling units built out is not germane.

Operating Cost Evaluation

1. If project revenues cannot fully pay operating costs, to what degree are other revenue sources available to pay for the shortfall? A number of sources could support a deficit at a central or regional treatment plant. However, a small community system's resource base is much smaller and largely confined to system users; thus, it has few sources of outside revenue.

2. The operating costs of each alternative should be assessed for sensitivity to changes in projected flow volumes, inflation, energy costs and availability, and scarcity of raw materials. Some systems will be highly dependent upon certain flow volumes being achieved in order to insure financial stability. Inflation will play a variable role depending upon the percent of budget attributable to labor costs, replacement parts, chemicals, etc. and the rate at which each of these items increases in cost. Some wastewater treatment processes are more energy intensive than others and the need for pumping stations plays a major role in energy costs. The need for any raw materials that are presently or are anticipated to be in short supply (and therefore expensive) due to third world political upheavals or natural disasters should be identified.

After worksheets have been completed for each alternative, a matrix which summarizes answers should be prepared and analyzed. In addition, the Technical Reference Document, Financial Planning Handbook for Wastewater Management, (Briscoe Maphis Murray & Lamont, Inc. 1981) contains a series of worksheets for evaluating community and household financial impacts.

(b) Financial Impacts of Storm Damage

Repair and replacement of wastewater management systems due to storm damage can represent a major community financial burden. Every effort should be made to minimize this type financial risk. When determining the suceptibility of the various wastewater management system alternatives to damage from storms, three system characteristics of the alternatives should be considered:

- Degree of centralization
- Amount of exposed structure
- Ability of systems to assimilate lower quality effluent.

Degree of Centralization

The assumption is that the more centralized a system is, the more likely general inconvenience and public health problems will occur due to the extensiveness in the disruption of service from storm damage. Therefore, the least centralized system (the on-site individual system) provides the most protection in that it serves a very small area and is not significantly affected by damage in areas outside its service area.

Amount of Exposed Structure

When evaluating the amount of exposed structure, the system alternatives may be classified as follows:

- Underground, few structural components, with subsurface disposal
- Underground, many structural components
  (Treatment systems include septic tanks, aerobic tanks, buried filters and holding tanks)
- Above ground, few structural components
  (Treatment systems include lagoons and marsh/pond systems; disposal systems include lagoons and spray irrigation facilities)
- Above ground, many structural components
  (Treatment systems include package plants, sewage treatment plants and oxidation ditches; disposal systems include ocean outfalls).

The assumption is that the more a system is exposed and structure-intensive, the more susceptible that system is to storm damage. This damage would result in a financial impact on the users for repairing or replacing the facilities. Storm damage to above ground facilities is assumed to result from high winds, strong rainfalls and flood inundation, whereas storm damage to underground facilities is normally due to high soil saturation levels that flood the systems. An example of the latter case is surface seepage from soil absorption systems and "pop-outs" of septic tanks and holding tanks after heavy rainfalls. In considering the amount of exposed structure, attention must also be given to the strength of the structure in resisting damage. A good example of this concern would be spray irrigation systems, which are quite susceptible to wind damage.

Ability of Systems to Assimilate Lower Quality Effluent

Lower quality effluent is a result of temporary impairment or temporary destruction of the treatment/disposal capabilities of the system. The systems are classified based on inherent storage capabilities in the treatment facilities relative to flow volumes. Treatment facilities with large storage capacity include lagoons, oxidation ditches, septic tanks, marsh/pond systems and sewage treatment plants with flow equalization. Treatment facilities with negligible storage capacity include aeration tanks, package plants, ocean outfall and sewage treatment plants without flow equalization.

The assumptions made for this evaluation are as follows:

1. Treatment facilities with large storage capacity can hold back low quality effluent until the total system is repaired and the wastewaters can receive the treatment required.

2. Ocean outfall disposal techniques can assimilate low quality effluent on a temporary basis without causing significant public health problems or environmental impacts. A temporary closing of the beaches to swimmers may result due to aesthetics and minor health concerns, but this affects only recreational concerns and only on a short-term basis. The important factor in this assumption is the large assimilation capacity of the ocean.

3. Inland surface water disposal is very sensitive to quality of discharged effluent due to its very low assimilation capacity, proximity to shellfish beds, and nexus with groundwater potable water supplies.

Table II.4 is a worksheet that should be used to assess susceptibility to storms. Each alternative should be rated regarding degree of centralization, amount of exposed structure and ability to assimilate lower quality effluent. More detailed analysis of the amount of exposed structure may be undertaken on a component-by-component basis (tanks, drainfields, buried pipe, exposed pipe at bridge crossings, pump station, rotary distributors, etc.) After each alternative receives its three ratings, the composite scores can be compared to assess level of risk.

(2) Primary and Secondary Environmental Impacts

Impacts may be primary, produced by the construction, operation and maintenance of the system, or secondary, derived in some fashion from the existence of the system and its capacity. These effects are also termed direct and indirect, respectively. Impacts may be characterized as short term (construction noise) or long term (loss of a species of fish or commitment of a land area for 20 years). The short or long term nature of the impact may be important in decision-making, since impacts acceptable to local populace on a short term basis are frequently not acceptable indefinitely. Impacts must also be considered either positive or negative. Effort expended in estimating impacts accurately may be extremely beneficial, since positive benefits not initially foreseen may emerge, or potentially severe adverse impacts can be avoided, mitigated or at least foretold.

The magnitude of impacts should be estimated. In some cases, quantification of the impact is possible (for example, "a shellfish bed yielding 10,000 lbs/yr can be reopened" or "100 acres of maritime hardwood forest will be lost"). However, quantification can be deceptive when applied to systems where the impacts differ only in degree. Arbitrary numerical quantification

Table II.4. Methodology for Evaluating the Susceptibility to Storm Damage for Each System Alternative.

System Characteristic	Classification of Systems	Level of Susceptibility		
		Low	Mod.	High
1. Degree of Centralization	Individual treatment and disposal	X		
	Individual treatment and community disposal		X	
	Community treatment and disposal		X	
	Regional treatment and disposal			X
2. Amount of Exposed Structure	Underground, few structural components	X		
	Underground, many structural components		X	
	Above ground, few structural components		X	
	Above ground, many structural components			X
3. Ability to Assimilate Lower Quality Effluent	Treatment System			
	Large storage capacity	X		
	Negligible storage capability			X
	Disposal Method			
	Subsurface, land application		X	
	Surface, land application	X		
	Inland surface water discharge			X
	Ocean outfall	X		

Source: Gannett Fleming Corddry and Carpenter, Inc. 1981.

of magnitude may lead to reliance on small differences in numbers which are individually not really quantifiable. The use of positive and negative descriptions can provide a range of identification without the use of numbers in arbitrary situations. Figure II.17 is a flowchart showing the steps necessary to complete this assessment.

Table II.5 is the layout of a worksheet which, when reproduced on a larger scale, can be used to evaluate environmental impacts. The entries on the worksheet should describe in narrative form the impacts of the proposed wastewater management system alternative on the natural or manmade environmental resource. A section of the worksheet should be completed for each system alternative. Thereafter, the worksheets may be laid side by side so that comparisons can be made about the differences in impacts between alternatives.

Primary, or construction-related impacts, tend to be relatively minor in barrier island communities, especially when on-site and small community systems are selected. Secondary impacts, however, can be extremely significant. Areas of major concern include groundwater resources, surface water resources, and impacts to sensitive natural areas. The EIS has developed specific procedures to ensure that the potential impact these resources is recognized during the development and evaluation of alternatives.

(3) Implementability

Procedures for assessing implementability must focus on engineering constraints, fiscal and institutional feasibility and socio-political acceptability. The engineering evaluation focuses largely on any constraints which must be acknowledged regarding construction or operation and maintenance of each proposed alternative. Construction constraints could include:

- Shortages of materials
- Shortages of construction crews trained in a particular skill
- Local lack of experience in a new construction technique
- Hazardous conditions.

Operation and maintenance concerns typically revolve around the following factors:

- Reliability of treatment, the ability of the process to consistently produce uniform treatment efficiencies and meet water quality standards
- Flexibility, the ability of the treatment process to adequately handle fluctuating wasteloads, variable flows, and new waste streams
- Operability, an analysis of the ease of operation and maintenance and considerations of the availability of trained operators and support personnel
- Energy usage
- Adherence to applicable state and local codes.

The EIS recommends developing a worksheet similar to Table II.5 where each alternative is evaluated in a matrix format. In this instance, environmental parameters would be replaced by construction constraints and operation and maintenance concerns in the left hand column of the worksheet.

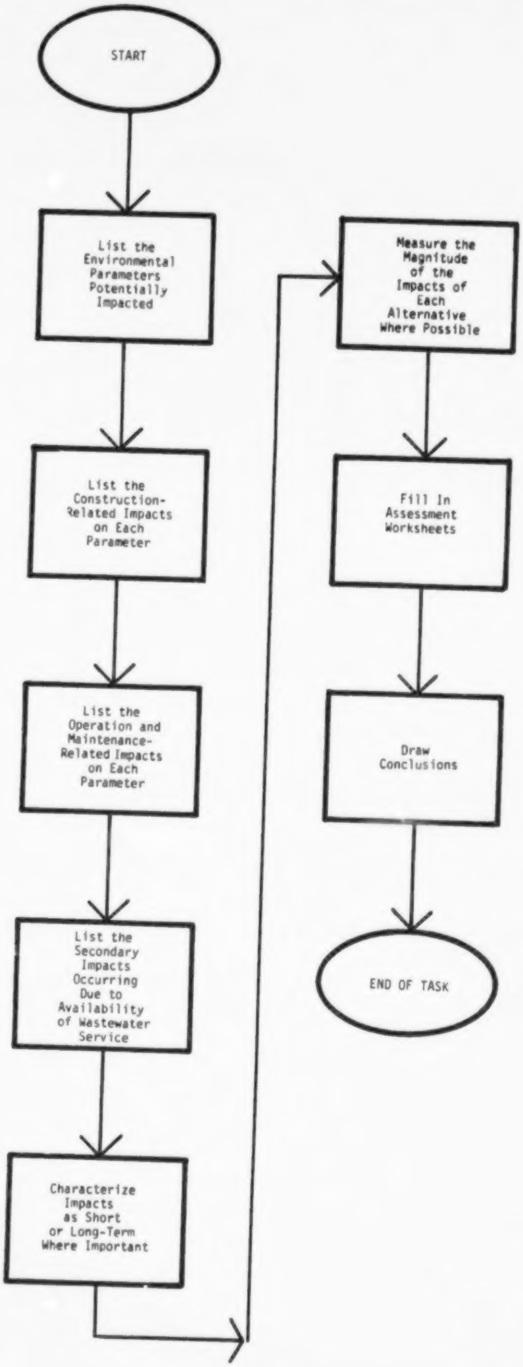

START
List the Environmental Parameters Potentially Impacted
List the Construction-Related Impacts on Each Parameter
List the Operation and Maintenance-Related Impacts on Each Parameter
List the Secondary Impacts Occurring Due to Availability of Wastewater Service
Characterize Impacts as Short or Long-Term Where Important
Measure the Magnitude of the Impacts of Each Alternative Where Possible
Fill In Assessment Worksheets
Draw Conclusions
END OF TASK

Figure II.17 Methodology for Evaluating Primary and Secondary Environmental Impacts of Wastewater Management Systems.

Source: Claude Terry & Associates, Inc. 1981

Table II.5. Environmental Impact Assessment Worksheet

Environmental Parameter	Alternative 1	Alternative 2	Alternative n
Natural Environment	Impact	Impact	Impact
Air Quality			
Odor			
Noise			
Threatened & Endangered Species			
Terrestrial Ecosystems			
Aquatic Ecosystems			
Soils			
Topography			
Geologic Resources			
Groundwater Quality			
Groundwater Quantity			
Surface Water Quality			
Surface Water Quantity			
Manmade Environment			
Population			
Land Use			
Public Health			
Economics/Employment			
Archeological/Historical Resources			
Natural Resource Utilization			
Recreation			
Transportation			
Community Services & Facilities			

Source: Claude Terry & Associates, Inc. 1981.

The evaluation of fiscal and institutional feasibility would be accomplished by comparing the worksheets (Table II.3) filled out for each alternative as well as worksheets on the Technical Reference Document Financial Planning Handbook.

The evaluation of the socio-political acceptability of each alternative is carried out mainly by means of the public participation program where comment from local officials and other affected parties is gathered.

2. Impacts of the Strategy

This section of the EIS describes the impacts that can be expected if the EIS Strategy is implemented. A comparison of these impacts with the impacts resulting from the other two strategies is reserved for Chapter IV. Impacts on development potential, financial impacts, implementability, timeliness and reliability are discussed below.

a. Impacts on Development Potential

An investigation was undertaken to ascertain if an adequate amount of land suitable for soil absorption systems was available to accommodate future growth. Concern has been expressed that development potential would be adversely impacted if central/regional facilities were not provided. The EIS analysis shows that more than adequate acreage suitable for soil absorption systems is available to support projected population levels.

(1) Land Capability Analysis: Existing Development

Existing development on the barrier islands has been surveyed to determine the relationship between soil suitability for on-site soil absorption systems and historic development patterns. Aerial photographs from the USDA Soil Conservation Service Soil Survey of the Outer Banks were used to correlate soils and development existing in 1977. These soils are listed in Table II.6. The following paragraphs describe the general survey findings.

(a) Sunset Beach

High land areas consist primarily of Newhan related soils #21, 22, 23 and 24, dredge spoil, Madeland, Corolla, and Carteret soils. Minimal Bohicket soils are also present. Existing development occurs exclusively on soils displaying more than 18 inches of depth to groundwater. The great majority (75 percent) of the development occurs on Newhan soils which are suitable for on-site conventional septic systems.

(b) Ocean Isle Beach

Newhan complex soils #21 and 22 are present along the entire length of Ocean Isle Beach. These soils are backed by Corolla #7 and Carteret #6 soils in undisturbed areas. Many acres of low Carteret soils have been altered by dredge and fill to create finger-fill canals on Madeland #17. Existing development is confined to the Newhan soils (80 percent) with the exception of those structures located on the Madeland (20 percent). Based on depth to seasonal high water table, the entire development appears to be located on soils suitable for on-site treatment systems.

Table II.6. Soils Identification Chart Listing Depth to Seasonal High Water Table.

Soil Type	Depth to Water Table	Soil Type	Depth to Water Table
1 Beach	1.0-3.0'	16 Levy soils	0.0-2.0'
2 Leon fine sand	0-3.0'	17 Madeland	3.0'
3 Beach-Foredune association	0.0-3.0'(beach) 6.0' (foredune)	18 Carteret soils, high	1.0-3.0'
4 Bohicket	0.0-3.0'	19 Carteret soils	0.0-3.0'
5 Tidal Flats	0.0-3.0'	20 Currituck soils	0.0-3.0'
6 Carteret, low	0.0-3.0'	21 Newhan fine sand	6.0'
7 Corolla fine sand	1.5-3.0'	22 Newhan-Corolla complex	6.0'
8 Corolla fine sand, forested	1.5-3.0'	23 Duneland-Newhan complex	6.0'
9 Corolla-Duckston	1.0-3.0'	24 Newhan-Urban land complex	6.0'
10 Dredge Spoil	3.0'	25 Wando fine sand	6.0'
11 Hobonny	0.0-2.0'	26 Conaby soils	0.0-1.0'
12 Duckston fine sand	1.0-2.0'	27 Echaw fine sand	2.5-5.0'
13 Duckston fine sand, forested	1.0-2.0'	28 Kureb fine sand	6.0'
14 Duneland	6.0'	29 Currituck soils, high	0.0-2.0'
15 Fripp fine sand	6.0'	30 Currituck soils, high	0.0-2.0'
		31 Bohicket soils, high	0.0-3.0'

NOTE: Soils with depth to seasonal high water table greater than 12 inches comprise 45.0 percent of study area lands (see Table 2.2.2-b).

Soils exhibiting <12" depth to seasonal high water table are unsuitable for on-site absorption systems.

Soils exhibiting 12" to 48" depth to seasonal high water table are considered suitable for modified on-site soil absorption systems.

Soils exhibiting more than 48" depth to seasonal high water table are considered suitable for conventional on-site soil absorption systems.

Source: U. S. Department of Agriculture Soil Conservation Service, Soil Survey of the Outer Banks, 1977.

(c) Holden Beach

Generally developable high land soils on Holden Beach consist of Newhan complex soils #21 and 22 and backed by Carteret #6 and dredge spoil #10 soils. Many acres (20 percent) of Carteret #6 soil have been converted to Madeland #17 by dredge and fill operations creating finger fill canals. Virtually all (95 percent) of the existing development not on finger-fill canals is located on the Newhan soils which are suitable for on-site conventional soil absorption systems.

(d) Southeast Brunswick County (Oak Island)

Oak Island contains three communities, Long Beach, Yaupon Beach, and Caswell Beach, situated on a beach strand and a forested island which display different soil types. The beach strand is comprised of about 90 percent Newhan complex soils #21, 22, 23 and 10 percent Duckston sands #12. Existing development is located exclusively (98 percent) on the highly suitable Newhan soils. The remainder of the island highland is located behind the beach strand and is comprised of forested uplands on Wando #29 and Kureb #28 sands (totaling 90 percent) interspersed with Leon #2 sands (ten percent) primarily along the island's margins. Existing development is scattered throughout this forested area, but the vast majority (>80 percent) appears to be located on the Wando and Kureb sands which are suitable for on-site wastewater treatment systems.

(e) Topsail/Surf City

Topsail Island supports three communities, Topsail Beach, Surf City and West Onslow Beach, all located on a narrow barrier island backed by water and low lying soils. Developable lands consist of Newhan complex soils (#21, 22), Wando sands #25, dredge spoil #10, Madeland #17 and Carteret soils #6, 18. All existing development (95 percent) along the beach front is located on the well drained Newhan soils. The remaining five percent of development is located on Madeland created from Carteret soils on the backside of the island.

(f) Bogue Banks (Atlantic Beach, Pine Knoll Shores)

This study area is characterized by high lands comprised of Newhan #22, 23, 24 and Fripp #15 soils backed by lower Carteret #6, 18, Duckston #12 and Corolla #9, 7 soils. In some locations major areas of Carteret #6 soils have been converted to Madeland #17 by dredge and fill operations to create finger-fill canal developments. Existing development is primarily (75 percent) located in Newhan and Fripp soils, excellent for conventional septic systems, with about five percent located on Corolla and about 20 percent built on Madeland.

(g) Hatteras Island

The seven communities (Rodanthe, Waves, Salvo, Avon, Buxton, Frisco, and Hatteras) encompassed by this 201 Plan extend along the estuarine side of Hatteras Island. Developable soils within the communities are comprised primarily of Duckston #12 and Corolla #7,8,9 soils, interspersed with Carteret

#18, #19 and Newham #21, 22 soils. Corolla and Duckston soils are more prevalent than in the other 201 Plan areas due to the location of these communities on the sound side of the island, rather than on the beachfront where Newham soils dominate. Existing development is located primarily (85 percent) in Duckston and Corolla soils which are capable of supporting modified on-site treatment systems. The remaining development is built on Madeland/dredge spoil (10 percent) and on the beach related Newham soils (5 percent).

(h) Dare Beaches (Bodie Island)

This 201 study area exhibits more soils diversity than the other project areas. This is due primarily to the age and size of the island. Soils present a striated appearance from ocean to sound starting with a large expanse of Beach/Foredune #3 adjacent to a band of Newhan #21, 22, 24 soils. The center and sound strands of Bodie Island soils are comprised of somewhat lower Duckston #12, Carteret #18, 19, and Corolla #7, 9, 8 soils in the southern portion of the study area. In the north around Kill Devil Hills, large dunes #14 and high wooded areas of Newhan #21, 23 are interspersed with small areas of Duckston #12, 13, Fripp #15, Corolla #7, 8, 9 and Conaby #26 and Hobonny #11 soils.

(i) Summary

Historical development patterns, as measured by an analysis of soil survey aerial photographs, appear to support the wisdom of previous landowners and builders in selecting the best land available for barrier island development. The vast majority of structures existing in 1977 were built on lands that are fully capable of providing adequate wastewater treatment using the prevailing technology: septic tanks and soil absorption fields. Much of the remaining land can accommodate this type of development, both raw land and areas available for infilling with additional structures. Additional large acreages of high land are suitable for other on-site systems (mounds, low pressure pipe systems).

(2) Land Capability Analysis: Appropriate Systems for the Future

The six 201 study areas have been assessed by mapping two data variables: sensitive natural areas and soil suitability for on-site wastewater management systems. The purpose of this exercise was to determine the land use capability of barrier islands based on the use of various wastewater management systems. Each 201 study area was divided into lands identified as sensitive (CAMA Areas of Environmental Concern and Registered Natural Areas) or non-sensitive (all other lands encompassed by the U. S. Soil Conservation Service in the Soil Survey of the Outer Banks). In addition, each study area was divided into areas suitable for some type of on-site soil absorption wastewater management systems (those lands with 12" or greater depth to the seasonal high water table) and those unsuitable for any form of on-site soil absorption systems (those lands with less than 12" depth to the seasonal high water table). Data for depth to seasonal high groundwater was derived from the Soil Survey of the Outer Banks and was described in Table II.6.

(a) Land Capability Classification System

Four categories were developed which combine sensitive/non-sensitive areas with suitable/non-suitable soils for determining the development potential of each island. Maps showing these categories are found in the Alternatives Evaluation Task Report. The four categories are described as follows:

Category 1: Suitable/Non-sensitive Lands:
These lands can support on-site soil absorption wastewater management systems, and they are not included in lands protected by the regulations governing Areas of Environmental Concern as identified by the North Carolina Coastal Management Program. These lands offer optimal development potential for barrier island uses.

Category 2: Unsuitable/Non-sensitive Lands:
These lands will not support on-site soil absorption systems, and they are not regulated by the Coastal Management Program. These lands are considered developable, but they will require wastewater management systems with off-site disposal in order to utilize the land.

Category 3: Suitable/Sensitive Lands:
These lands consist of soils capable of supporting on-site soil absorption systems, but due to their environmentally sensitive nature, a use permit is required from the N.C. Coastal Management Program which assures that development is compatible with the protected resource. Therefore, while the land is considered developable in many instances, specific siting and building criteria must be implemented to allow project construction.

Category 4: Unsuitable/Sensitive Lands:
These lands are incapable of supporting on-site soil absorption systems, and they are protected by regulations governing Areas of Environmental Concern. Lands within this category are considered largely undevelopable as they consist primarily of ocean hazard lands and marshlands.

(b) Land Capability of Each Study Area

Table II.7 shows the number of acres of land in each of the four categories per 201 study area. Lands with greater than 12 inches to seasonal high water table comprise 45.0 percent of the total land area. Of the remaining 55.0 percent of land, approximately 38.2 percent is marshes and wetlands. The Alternative Evaluation Task Report discussed the land capability of each study area in detail.

(c) Development Potential of Each Land Category

The four land categories identified are significant because they indicate the relative development potential of all lands in each study area. Category 1 lands are good sites for development because they present no significant environmental problems (erosion, wetlands, critical habitat) and also allow on-site soil absorption wastewater management systems. Such lands range from a low of 13.2 percent in the Topsail/Surf City area to a high of 38.5 percent in the Southeastern Brunswick County area.

Table II.7. Acres by Sensitive Area/Soil Absorption System Suitability Category

Land Capability Category 201 Plan	Category 1		Category 2		Category 3		Category 4		
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Total Acres
Southwestern Brunswick Co.	1409	20.2	317	4.5	1395	20.0	3855	55.3	6976
Southeastern Brunswick Co.	2988	38.5	372	14.8	1125	14.5	3277	42.2	7762
Topsail/Surf City	1074	13.2	905	11.2	1161	14.3	4967	61.3	8107
Carteret Co./Bogue Banks	1276	30.6	413	9.9	1340	32.2	1138	27.3	4167
Hatteras Island	2437	27.0	2850	31.5	1808	20.0	1946	21.5	9042
Dare Beaches	4861	34.3	3397	24.0	1905	13.4	4007	28.3	14,170
Totals	14,045	28.0	8,254	16.4	8,734	17.4	19,190	38.2	50,224

Category 1 = >12" to groundwater and non-sensitive
Category 2 - <12" to groundwater and non-sensitive
Category 3 = >12" to groundwater and sensitive
Category 4 = <12" to groundwater and sensitive

Source: ERDAS, Inc. 1981.

Category 2 lands can be developed without significant environmental effects, but the builder must determine how wastewater management will be provided since on-site systems are not feasible. In this case, community systems using off-site disposal may be appropriate for multi-unit projects. Single unit or small projects may use composting toilets or other similar alternative and innovative wastewater treatment systems. Another potential solution to wastewater problems on non-suitable soils is to transport effluent to an adjacent site which has more than 12 inches of depth to the seasonal high water table. Figure II.18 illustrates this concept and shows how a 40-house subdivision could be built on a tract containing a combination of Category 1 and 2 lands. In cases where communities or subdivisions use this technique, the disposal site could be used as a park or open space for all participating land owners. Percentages of land in Category 2 tend to be quite small with the exception of the Dare Beaches and Hatteras Island area where Category 2 lands represent 24.0 and 31.5 percent of total land.

Category 3 lands are considered suitable for development with soil absorption wastewater treatment systems, but these lands display sensitive natural features which constrain the use of the land. Siting considerations (setbacks, land area requirements, use restrictions) and design requirements may affect the development potential by requiring special construction or site design features. Additional cost may reduce the development potential, but the added design features might also increase the desirability of the location (ocean-front, marsh view, etc.), thereby resulting in a higher return on investment. This category tends to include less than 20.0 percent of the total land in each study area except Carteret County where much of this category land has already been developed.

Environmental considerations are identified and described by the Coastal Management Program and include ocean hazard areas, natural and cultural resources, and public water supplies. Archeological and historical resources listed on the Historic Register are also identified. In addition, Registered Natural Areas as identified and designated by the North Carolina Department of Natural Resources and Community Development are included in the sensitive areas description of this category.

Figure II.19 serves as a basis for analyzing development potential in the following sections of the report. Table II.8 displays the development potential of each study area if soil absorption systems are utilized on those lands deemed developable (non-Category 4). Category 1 lands have full potential and Category 2 and 3 lands have partial potential as described previously. For discussion purposes, 25 percent of Category 2 and 75 percent of Category 3 lands are assumed to be capable of being developed using soil absorption systems. Table II.8 shows that at least two-thirds of developable land (Hatteras Island - 63.5 percent) in each study area can be developed using on-site or small community soil absorption systems.

Development potential on Category 4 lands is the lowest of the categories presented because of the development costs involved in meeting environmental standards and providing off-site wastewater management systems. In many instances the risk of developing in these areas is also increased as protected resources are often more prone to flooding and storm damage than those lands in Categories 1, 2, and 3.

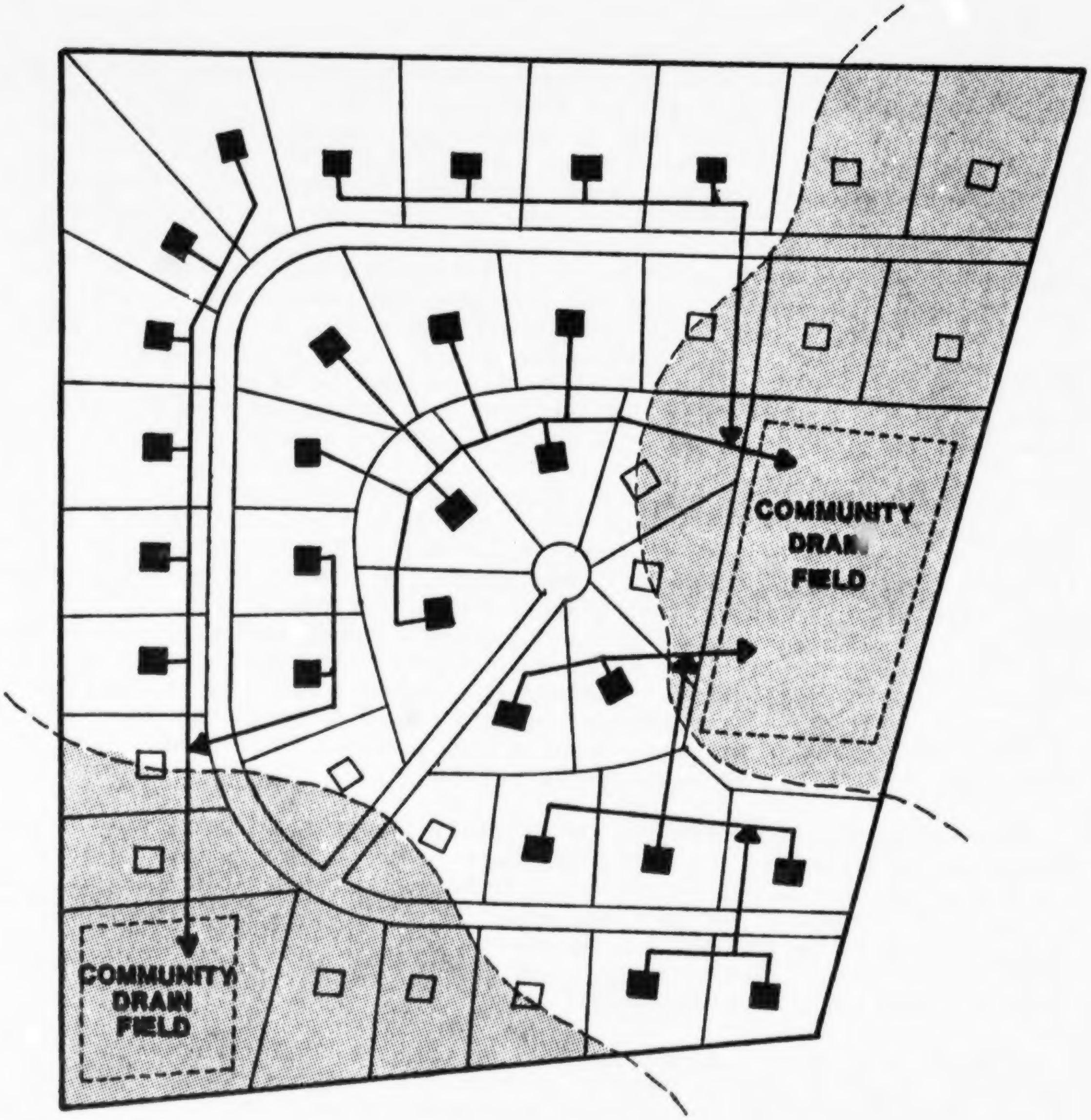

COMMUNITY
DRAIN
FIELD
COMMUNITY
DRAIN
FIELD

Figure II.18 **SUBDIVISION CONCEPT PLAN**

☐ **HOUSES USING ON-SITE DISPOSAL (14)**

■ **HOUSES REQUIRING OFF-SITE DISPOSAL (26)**

▨ **GREATER THAN 12" TO SEASONAL HIGH WATER TABLE**

☐ **LESS THAN 12" TO SEASONAL HIGH WATER TABLE**

SOURCE: CLAUDE TERRY & ASSOCIATES , INC. 1981

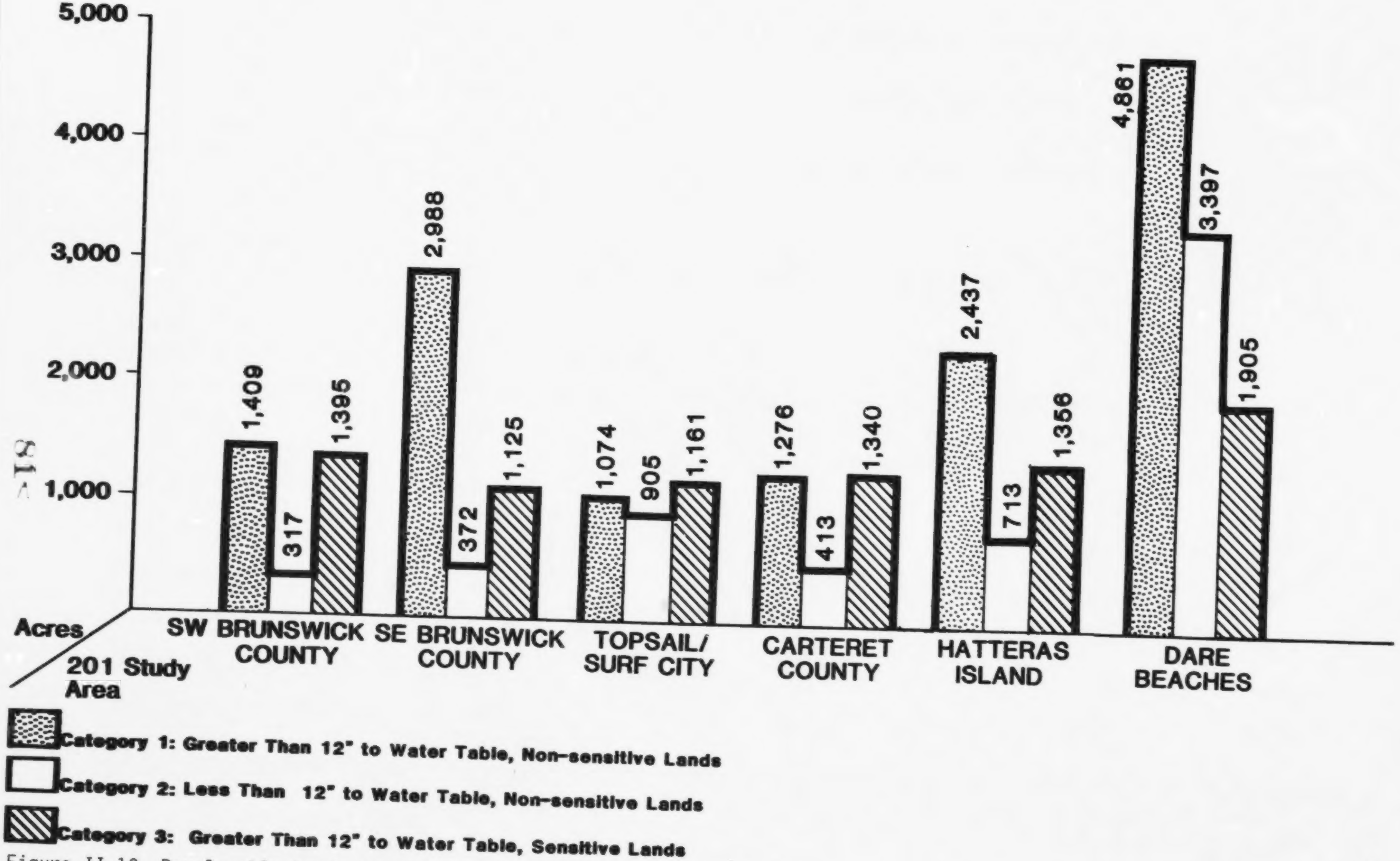


Figure II.19 Developable Lands in Each 201 Study Area (see Table II.6)

Source: Claude Terry & Associates, Inc. 1981

Table II.8. Development Potential with Soil Absorption Systems.

Land Capability Category / 201 Plan	Category 1 (100%)	Category 2 (25%)	Category 3 (75%)	Acreage* Developable	Total Acreage in Categories 1, 2, and 3	% of Total Acres Developable**
Southwestern Brunswick Co.	1409	79	1049	2537	3121	81.3
Southeastern Brunswick Co.	2988	93	843	3924	4485	87.5
Topsail/Surf City	1074	226	871	2171	3140	69.1
Carteret Co.	1276	103	1005	2384	3029	78.7
Hatteras Island	2437	713	1356	4506	7095	63.5
Dare Beaches	4861	849	1429	7139	10,163	70.2
Totals	14,045	2,063	6,553	22,661	31,033	73.0

Category 1 = >12" to groundwater and non-sensitive
Category 2 = <12" to groundwater and non-sensitive
Category 3 = >12" to groundwater and sensitive

*This column represents the sum of those fractions of Category 1, 2 and 3 lands which can reasonably be expected to be developed using soil absorption systems.

**This column represents Column 4 divided by Column 5.

NOTE: Category 2 lands are assumed to be 25% developable if adjacent suitable soils are used for soil absorption systems.

Category 3 lands are assumed to be 75% developable under existing CAMA, cultural resource, and natural area regulations.

Use of Category 2 lands is based on siting soil absorption systems on suitable soils in Categories 1 and 3.

Source: Claude Terry & Associates, Inc. 1981.

(3) Land Capability Analysis: Population and Flows

The impact on development potential from the widespread use of soil absorption systems has been an ongoing issue in this EIS. The new North Carolina Laws and Rules for Ground Absorption Sewage Treatment and Disposal Systems (effective July 1, 1982 and amended January 1, 1983) have been analyzed to determine what minimum lot sizes will be required for single family, townhouse and apartment dwelling units. A repair area is not required under the following conditions (.1945 (c)) for a lot:

1. which is specifically described in a document on file with the local health department on July 1, 1982, or which is specifically described on a recorded deed or a recorded plat on January 1, 1983; and

2. which is of insufficient size to provide a repair area equal in size to the original nitrification field as determined by the local health department; and

3. on which a ground absorption sewage treatment and disposal system with a design daily flow of no more than 480 gallons is to be installed; or on which a ground absorption sewage treatment and disposal system with a design daily flow of more than 480 gallons is to be installed if application for an improvements permit is received by the local health department on or before April 1, 1983.

Thus, the 5,000 square foot lots platted prior to July 1, 1977, can still be developed with soil absorption systems but without a repair area. Lots of 7,500 square feet appear to be the minimum size that can be developed on sandy soils with a soil absorption system that includes a repair area. Townhouses can be developed at the density of six to eight units per acre depending upon the amenities package offered by the complex. Apartment units can range as high as 18-20 units per acre with no amenities. Appendix E contains diagrams of lot layouts and supporting text.

Each community will contain different percentages of these types of residential units. For planning purposes, 40 persons (or 20 bedrooms) per acre appears adequate for land consumption analyses.

Land acreages identified previously as suitable for development with soil absorption systems provide a mechanism for determining the carrying capacity of each 201 study area. Based on the number of housing units that can legally be accommodated by a given parcel of platted land (assume an average of five four-bedroom houses/acre) a maximum population can be projected. Table II.8 shows that developable acreage of highland using soil absorption systems ranges from 63.5 percent of available land in Hatteras Island to 87.5 percent in the Southeastern Brunswick 201 study area. If these developable acres were used for residential construction as permitted in the North Carolina Division of Health Services regulations governing on-site wastewater treatment systems, potential development can be quantified in terms of population and wastewater flows.

Figure II.20 contrasts the number of persons who could be served by soil absorption systems with the year 2000 peak population projected in the draft 201 Plans. As can be seen by these figures, the potential populations greatly exceed population projections.

The lack of centralized sewer systems should not preclude future growth, based on technical considerations. Other factors may affect development potential, however. Examples include downturns in the national and regional economies, depression of the housing industry, high interest rates, future shortages of gasoline, degradation of natural resource amenities by nonpoint source pollution, etc.

(b) Financial Impacts

The financial impacts to be evaluated are twofold. First and most important are overall total costs regardless of who is to pay (total present worth and/or total annual average). These are the prime cost criteria defined by EPA regulations. Second, it is necessary to evaluate local costs in terms of affordability. This considers distribution of costs (for example, grants received reduce local shares). EPA defines affordability in terms of percent of median household income for costs of proposed systems. This is the average cost for the average residential household. Projects which exceed the defined criteria are not necessarily prohibited, but they would call for special re-evalations and procedures.

Financial impacts are a major area of concern in this EIS. Local financial bases are small, and questions have been raised in discussions with local officials and citizens about the ability of island communities to bear the capital and operation and maintenance costs of central or regional wastewater management systems. As a consequence, this section of the EIS explores in considerable detail the costs and local financial burden of a variety of on-site and small community soil absorption systems which might be alternatives to systems proposed by the draft 201 Plans.

A case study of a hypothetical barrier island was developed as a mechanism to simulate various cost scenarios. First, costs were developed for a variety of potentially appropriate technologies. Then, several service scenarios using these technologies were developed, and the costs of each were analyzed. Details of the case study are found in the Alternatives Evaluation Task Report; major points are summarized below.

(1) Small Community System Costs

Costs for several small community systems are tabulated in Table II.9. These systems were designed for various flows based on local costs and actual conditions on the barrier islands. A 7 3/8 percent interest rate and 20 year time period were assumed. Land costs of $55,000 per acre were used.

Communities lacking access to a centralized treatment/disposal system often employ package treatment units. A wide variety of treatment/disposal options are available. Costs for two possible systems are included in Table II.9, an extended aeration package plant with disposal by rotary distribution and a contact stabilization package plant with disposal by spray irrigation. The costs for a typical household are lower for the contact stabiliza-

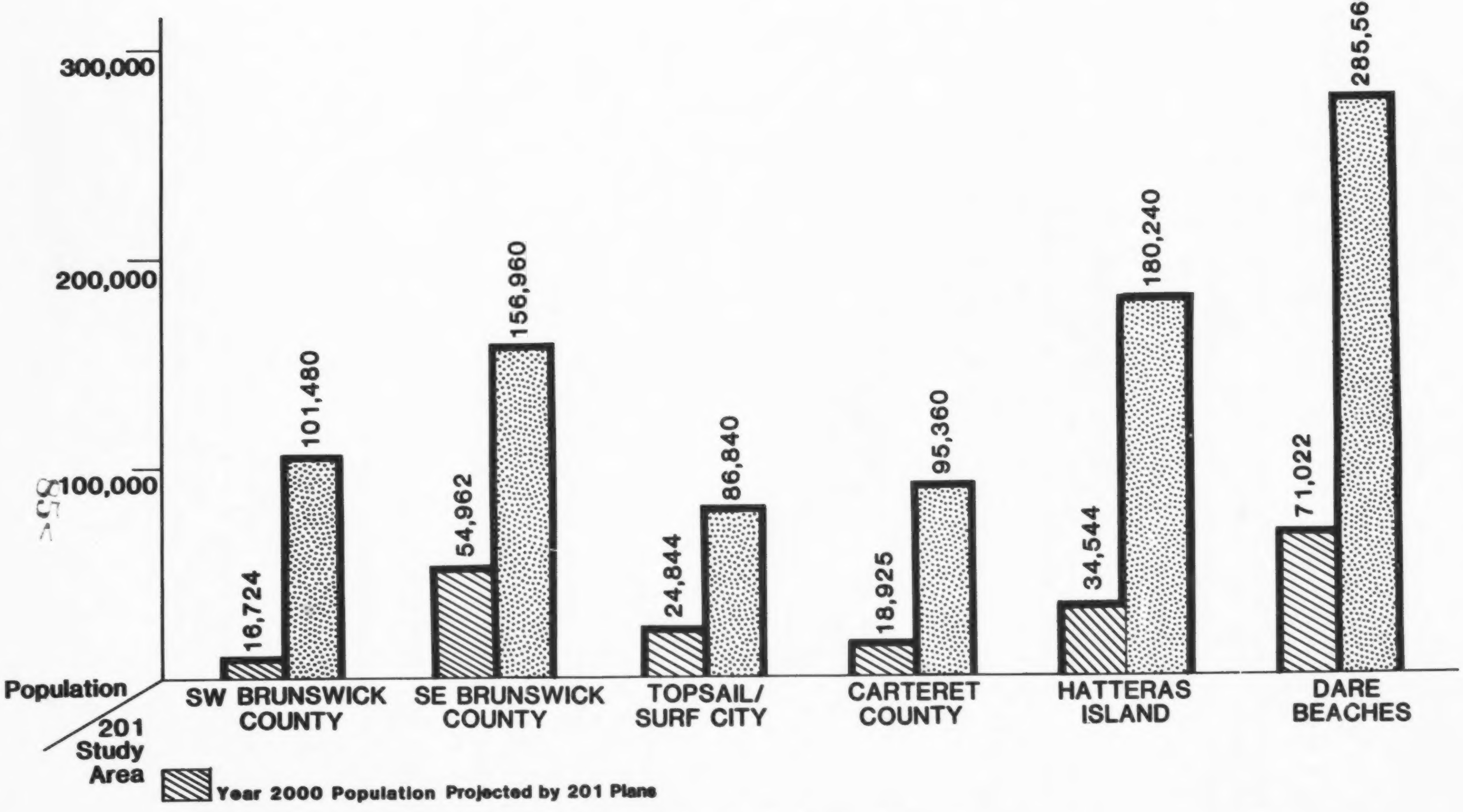


Figure II.20 Population Projections and Developable Land Comparison

Source: Claude Terry & Associates, Inc. 1981

tion/spray irrigation system than for the extended aeration/rotary distribution system. It should be noted, however, that the spray irrigation system was assumed to be built on a golf course and land costs are not included.

Existing communities which utilize septic tanks and need a solution to failing absorption fields may consider a septic tank effluent pump (STEP) and community absorption field system. This system uses low pressure pipes to convey septic tank effluent to the community absorption field. Costs for this system were developed assuming all dwelling units had existing septic tanks.

A septic tank can also be designed as a small community system. One large tank or a series of small tanks can be used. Generally speaking, a community septic tank/soil absorption system is most appropriate for lower flows. If an improved quality effluent from a community septic tank is desired before disposal to the absorption field, a recirculating sand filter may be added to the system. This filter would lower suspended solids concentrations, thus lowering the potential for clogging of the soil absorption field.

The total monthly costs per typical household shown in Table II.9 do not take into account the possibility of federal or state funding except in the last column. Small community systems would be eligible for funding if the residence or commercial establishment were constructed and in use prior to December 27, 1977 (EPA memo 1981). Systems serving new development are not eligible for funding. The existence of a community management agency is necessary to apply for funding.

Should federal and state assistance be available, families could expect their Total Monthly Cost per Household figure to drop to the levels shown in the last column. These figures are premised on 60 percent of total capital costs for conventional systems and 75 percent of total capital costs for innovative and alternative systems being funded from federal and state sources. Since not all capital costs are grant-eligible, figures less than 75 percent and 85 percent respectively were chosen to be applied to total capital cost figures. It should be noted that EPA construction grants will be reduced from 75 percent to 55 percent for conventional systems and from 85 percent to 75 percent for innovative and alternative systems after October 1, 1984.

(2) Individual On-Site System Costs

The most commonly used on-site system is a septic tank/soil absorption field. The costs of such a system for a typical single-family dwelling are presented in Table II.10.

A modification of a conventional soil absorption field is the use of pressure dosing in the field. This distributes the septic tank effluent more evenly over the absorption field and prevents the overloading of portions of the field, which may occur with conventional fields due to intermittent flows. The costs of a septic tank/pressure dosed field, however, are more than double the costs of a conventional septic tank/absorption field.

Table II.9. Costs of Small Community Systems.

System	Capacity (gpd)	Capital Costs ($)	Annual O&M ($/yr)	Total Annual Costs ($/yr)	Present Worth ($)	Total Monthly Cost per Typical Household	Total Local* Monthly Cost per Typical Household
Extended Aeration/ Rotary Distributors	140,000	1,039,500	29,100	138,800	1,315,200	24.60	12.95
Extended Aeration/ Rotary Distributors	94,000	690,700	23,280	96,150	911,300	25.05	13.65
Contact Stabilization/ Spray Irrigation	240,000	1,291,300	46,380	182,600	1,730,800	18.76	10.35
STEP System/ Soil Absorption Field	140,000	1,166,400	17,750	140,800	1,334,600	24.95	8.60
STEP System/ Soil Absorption Field	29,400	205,500	3,470	25,200	238,400	21.00	7.40
Septic Tank/ Soil Absorption Field	12,500	80,320	450	8,920	84,600	17.30	5.00
Septic Tank Soil Absorption Field	10,800	76,900	400	8,510	80,690	19.15	5.45
Septic Tank/ Recirculating Sand Filter/Soil Absorption Field	12,500	158,900	500	17,260	163,600	33.45	9.10
Septic Tank/Recirculating Sand Filter/Soil Absorption Field	10,800	149,120	450	16,180	153,400	36.44	9.85

*Assume capital costs are grant eligible.

Table II.10. Costs of On-Site Systems.

I. Conventional Systems

A. Construction Costs:

1. Septic Tank (1,000 gal.)	$ 300.00
2. Soil Absorption Field (300 ft^2)	600.00
Total Cost	$ 900.00

Will handle up to 450 gal/day, using the 201 plan factors of 4.2 persons/unit and 70 gal/day.

Use $900 per single-family residential unit.

B. Maintenance Requirements:

Pump-out every 4 years: $75/4 = $19 per year

C. Typical Household cost = ($900 x .1055) + $19 = $114/Household/year or $9.49/Household/month

D. Typical Household Cost (grant eligible)[1] = .075 ($900 x .1055) + $19 = $26/Household/year or $2.17/Household/month

II. Septic Tank w/Pressure Dosed Field

A. Construction Costs:

1. Septic Tank	$ 300.00
2. Field	600.00
3. Pump & Tank	1000.00
Total Cost	$1900.00

B. Maintenance Requirements:

1. Tank pump out	$ 19/yr
2. Pump O&M	20/yr
Total Cost	$ 39/yr

C. Typical Household Cost = ($1,900 x .1055) + $39 = $240/Household/year or $19.95/Household/month

D. Typical Household Cost (grant eligible)[1] = .075 ($1,900 x .1055) + $39 = $54/Household/year or $4.50/Household/month

III. Mound Systems

A. Construction Costs:

1. Septic Tank (1,000 gal)	$ 300.00
2. Elevated Mound (1,800 sq.ft.)	1,300.00
3. Effluent Pump and Tank	1,000.00
Total Cost	$ 2,600.00

NOTE: Septic tank not required on a replacement system.

Table II.10. Continued

B. Maintenance Requirements:
  1. Septic tank pump out every 4 years = $19/yr.
  2. Pump operation and maintenance = $20/yr.
  Total Costs $39/yr.

C. Typical Household Cost = ($2,600 X .1055) + $39 = $313/Household/year or $26.11/Household/month

D. Typical Household Cost (grant eligible)[1] = .075 ($2,600 x .1055) + $39 = $60/Household/year or $5/Household/month

IV. Composting Toilet; Graywater Septic Tank/Soil Absorption Field

A. Construction Costs:

1. Composting Toilet	$ 2,300.00
2. Septic Tank (1,000 gal)	300.00
3. Soil Absorption Field (300 ft^2)	600.00
	$3,200.00

B. Maintenance Requirements:
  1. Tank pump out $ 19/yr

C. Typical Household Cost = ($3200 X .1055) + $19 = $357.00/Household/year or $29.72/Household/month

D. Typical Household Cost (grant eligible)[1] = .075 ($3,200 x .1055) + $19 = $45/Household/year or $3.75/Household/month

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Notes: [1] Grant eligible costs assume 85 percent federal assistance and 7.5 percent state assistance.

Source: See Table 2.3.1 in Alternatives Evaluation Report.

Where high groundwater conditions exist, septic tank effluent can be discharged to a mound system. Pressure dosing is incorporated into these systems when it is necessary to pump the effluent up to the mound.

The costs for a composting toilet with a conventional septic tank/soil absorption field for graywater flow are also presented. Because the volume of graywater is a large percentage of the total volume of wastewater from a single family dwelling and regulations do not address the possibility of graywater systems, use of the composting toilet will not significantly reduce the size of the septic tank/soil absorption field needed, and these costs will not change. Discharging only graywater to the system, however, may increase the life of a soil absorption field because of the lower solids concentration and slightly lower flow. Under certain conditions, this may be an important benefit.

(3) Affordability Analysis

Typical household monthly charges were developed for the draft 201 Plans and various small community and individual on-site systems. A major concern of the EIS is how affordable are these monthly user charges. EPA guidance specifies that user charges for a household should not exceed 1.0 percent of median household income for families earning less then $10,000, 1.5 percent of median household income for families earning $10,000-17,000 annually or 1.75 percent of median household income for families earning over $17,000 annually. If these guidelines are exceeded, special evaluations and procedures are necessary.

Table II.11 shows estimated average family income in 1980 in the four counties making up the 201 planning areas. Median county income figures were not available, nor were figures for specific island municipalities available. As a general planning guideline, it appears that the maximum user charges for systems funded by 201 Construction Grants program monies should range between $18.74 and $24.82. Such figures will need further refining at the detailed planning level to relate them more specifically to the median income of permanent residents of each barrier island community.

Figure II.21 is a bar chart relating the typical household monthly charges of various wastewater management technologies in each study. A range of charges is shown for groups of technologies. Monthly charges with and without federal and state funding assistance are shown as appropriate. Individual on-site systems are assumed to be ineligible for funding assistance in this comparison. (Systems in place before December 1977 are eligible; future individual on-site systems are not eligible.)

Monthly user charges were calculated by dividing total annual user costs by 12. Local governments may chose alternative methods of distributing costs.

In all of the planning areas, the costs of the 201 Plans exceeds the EPA user fee ceiling by a significant margin if no federal and state funds are available. Many of the small community systems and some of the modified individual on-site systems appear very expensive relative to the local resource base. The reader should not be misled regarding individual or community systems, however. The EPA percent of income criteria applies to the average

Table II.11. Average Household Income and Maximum User Charge per Household by 201 Study Area County.

County	1980 Population	1980 Housing Units	Persons/ Household	1979 Per Capita Income**	Estimate Ave. Countywide Household Income	Maximum User Charge /Household***	
						Annual	Monthly
Brunswick	35,377	12,409	2.85	5,598	$15,954	$239.31	$19.94
Pender (Topsail/Surf City)	21,537	7,511	2.87	5,224	14,993	224.90	18.74
Carteret	39,324	15,128	2.60	6,545	17,017	297.80	24.82
Dare	13,169	5,359	2.46	6,559	16,135	242.03	20.17

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*U. S. Department of Commerce. Bureau of Census. 1981. 1980 Census.

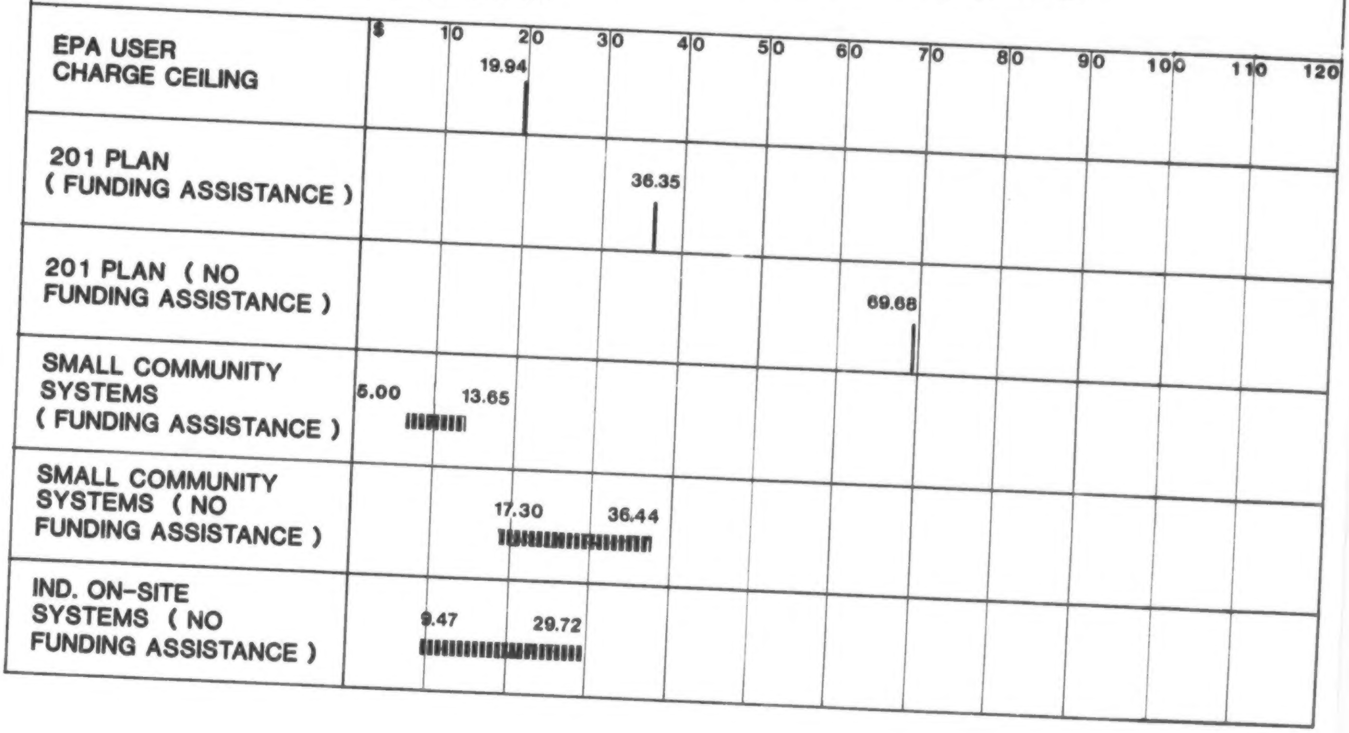
**U. S. Department of Commerce. 1979. Bureau of Economic Analysis.

***EPA regulations set a maximum user charge of 1.5 percent of median household income for households of $10,000-17,000 per year and 1.75 percent for households over $17,000 per year. If costs are higher, special evaluations and procedures are necessary.

Source: Claude Terry & Associates, Inc. 1981.

FIGURE II.21

SOUTHWESTERN BRUNSWICK COUNTY
COMPARISON OF EPA USER CHARGE CEILING WITH TYPICAL HOUSEHOLD COST PER MONTH FOR EACH TECHNOLOGY GROUP



SOUTHEASTERN BRUNSWICK COUNTY:
COMPARISON OF EPA USER CHARGE CEILING WITH TYPICAL HOUSEHOLD COST PER MONTH FOR EACH TECHNOLOGY GROUP

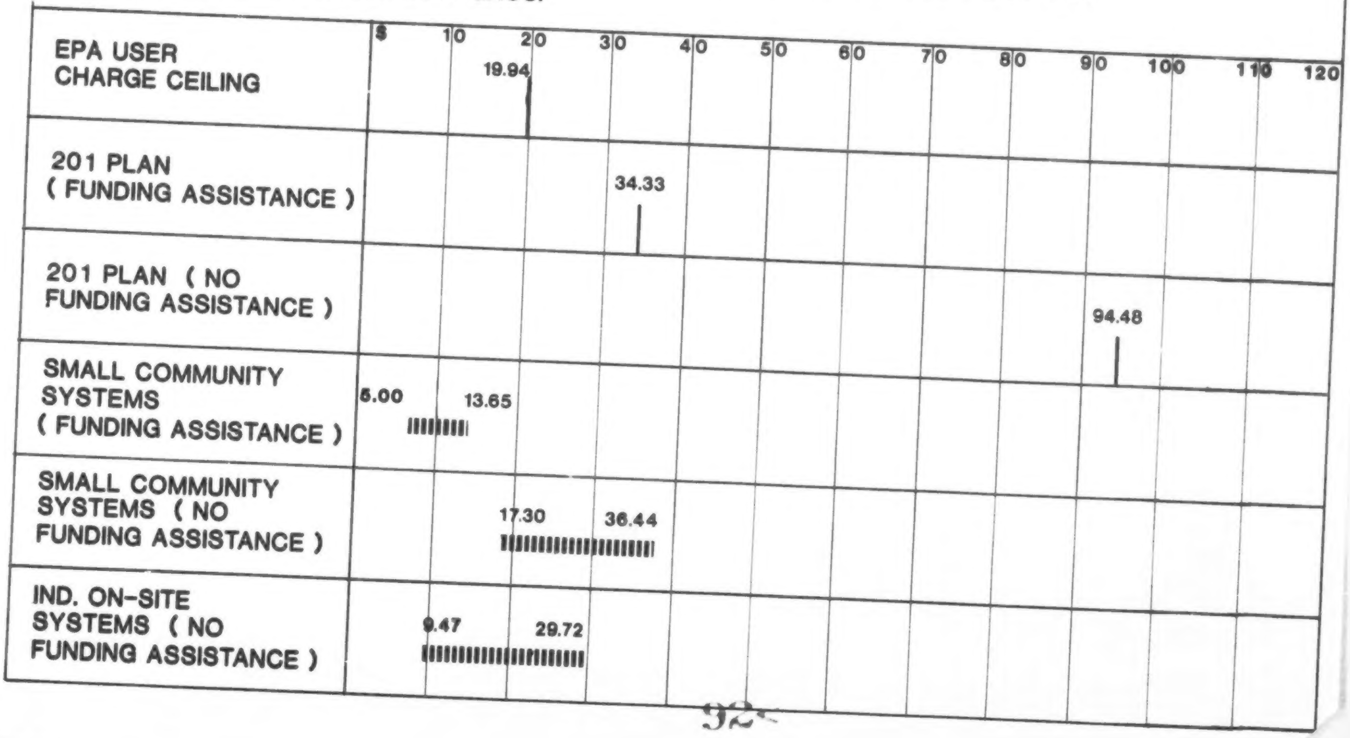
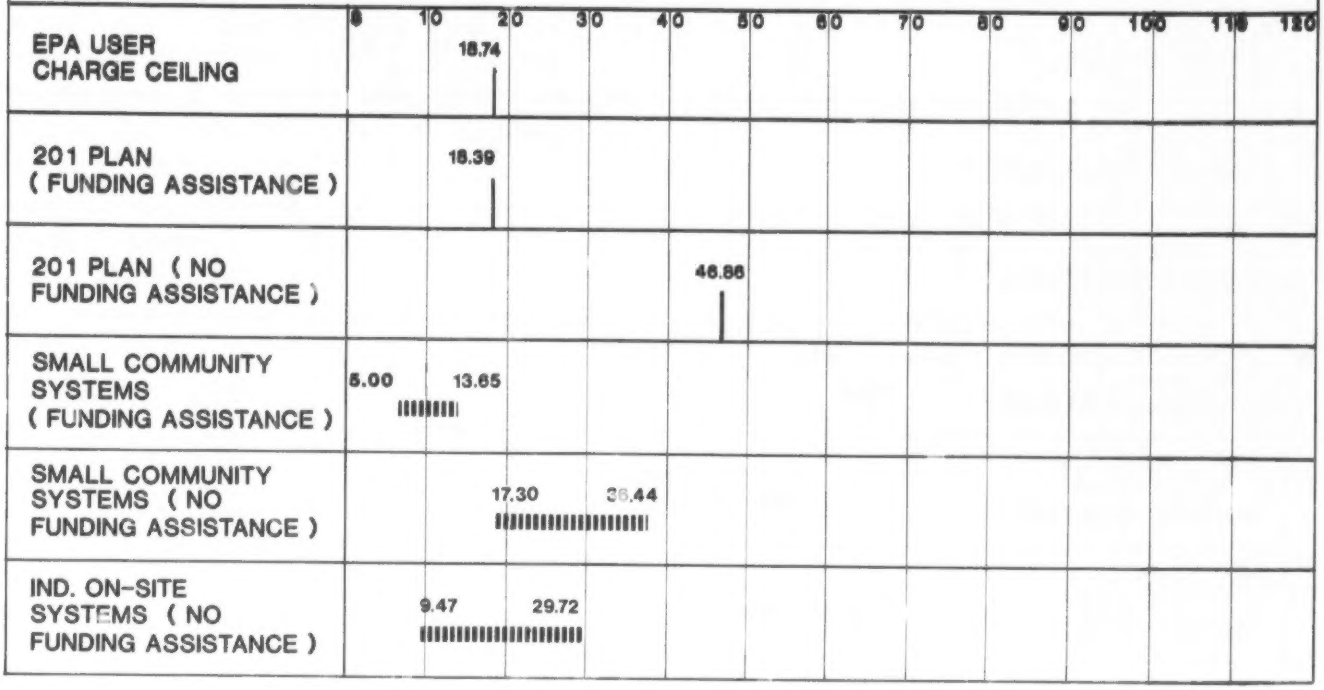


FIGURE II.21 (CONT.)
TOPSAIL / SURF CITY:
COMPARISON OF EPA USER CHARGE CEILING WITH TYPICAL HOUSEHOLD COST PER MONTH FOR EACH TECHNOLOGY GROUP



CARTERET COUNTY:
COMPARISON OF EPA USER CHARGE CEILING WITH TYPICAL HOUSEHOLD COST PER MONTH FOR EACH TECHNOLOGY GROUP

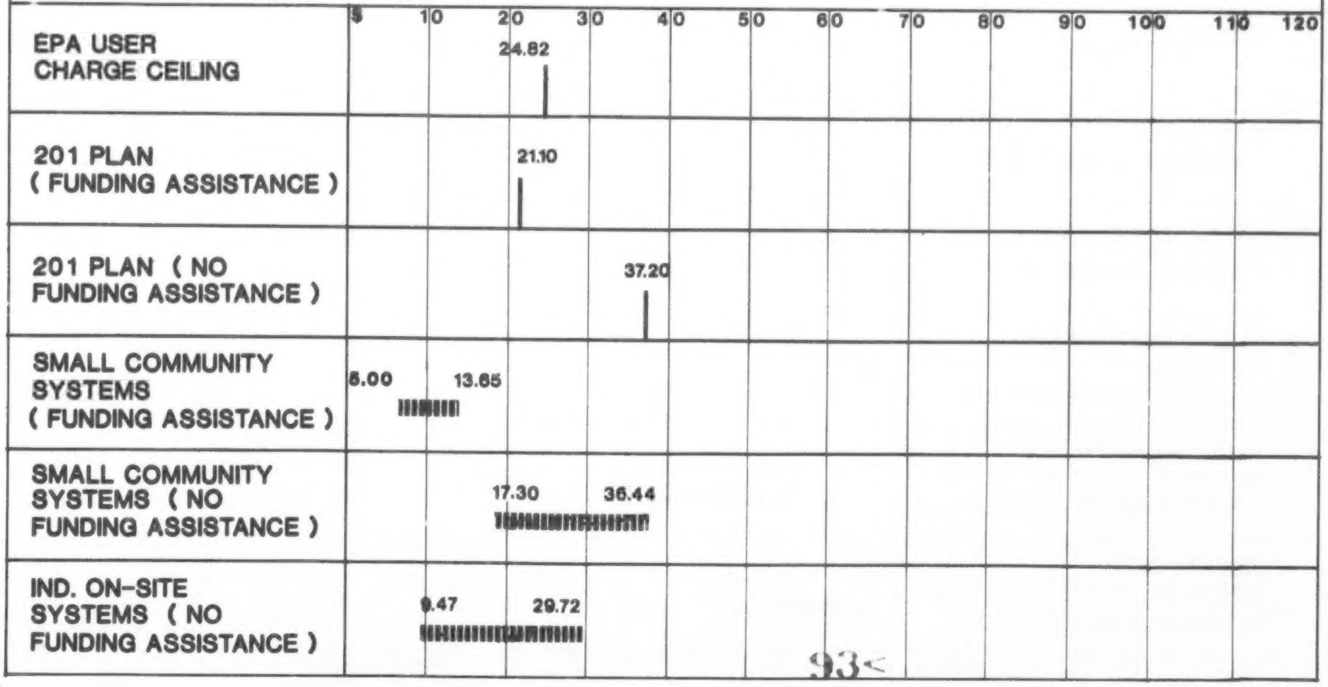
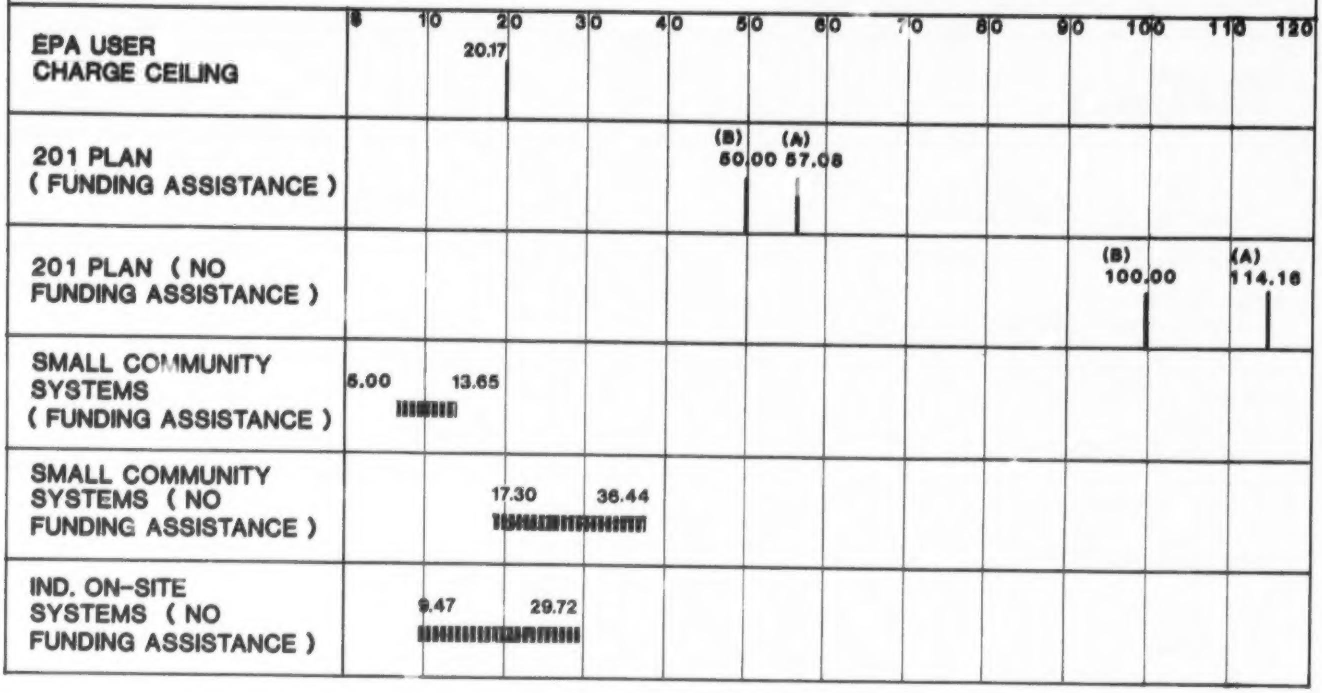
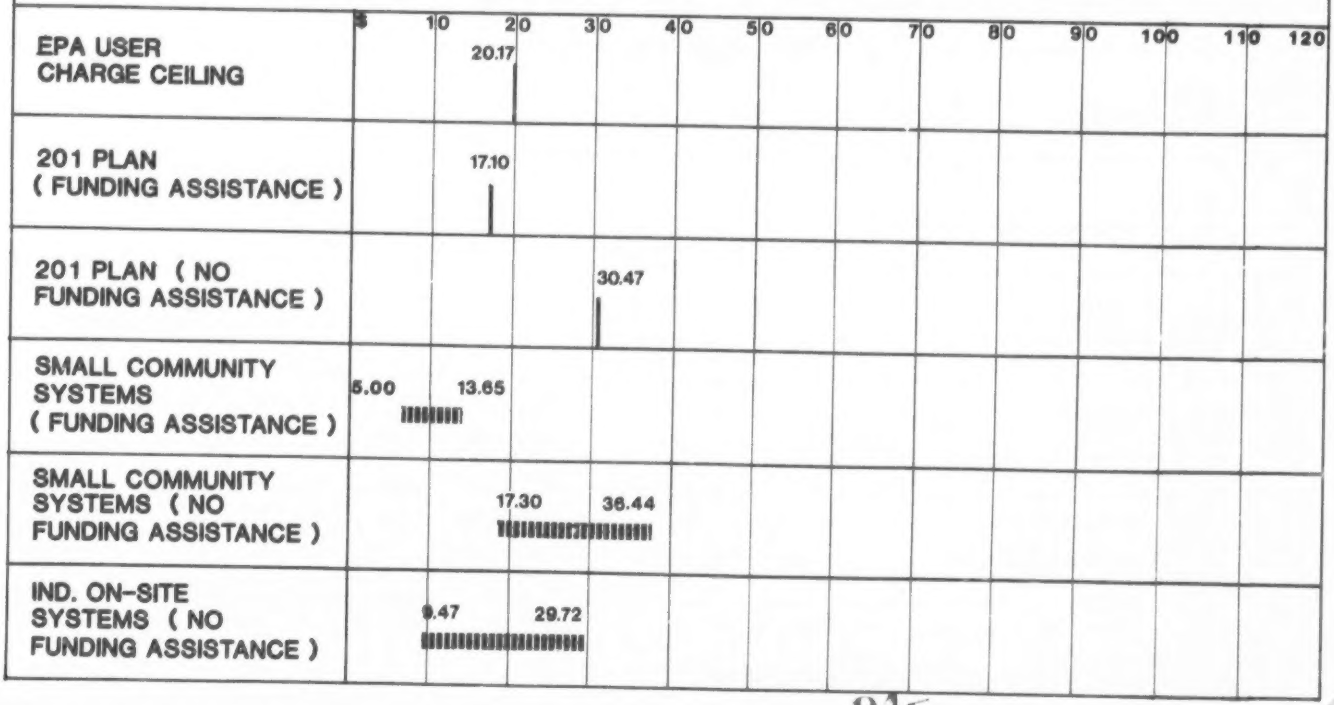


FIGURE II.21 (CONT.)
HATTERAS ISLAND: A) Avon/Buxton/Frisco/Hatteras B)Rodanthe/Waves/Salvo
COMPARISON OF EPA USER CHARGE CEILING WITH TYPICAL HOUSEHOLD COST PER MONTH FOR EACH TECHNOLOGY GROUP



DARE BEACHES COMPLEX:
COMPARISON OF EPA USER CHARGE CEILING WITH TYPICAL HOUSEHOLD COST PER MONTH FOR EACH TECHNOLOGY GROUP



Source: Gannett Fleming Corddry and Carpenter, Inc. 1981

cost of all these residents in the area. While a few residences might require the more expensive on-site systems, the average cost for the area should be determined and compared with the percent of income criteria. In such cases, on-site systems may be easily affordable.

Federal and state assistance, however, bring many small community systems down in cost into the affordable range. Monthly user charges for three of the five draft 201 Plans also fall below the EPA guideline ceiling. The Southeastern Brunswick County, Southwestern Brunswick County, and Hatteras Island proposed 201 Plans are significantly higher than the EPA guideline ceiling.

c. Implementability

Difficulties in implementing any of the three strategies can be anticipated mainly in the areas of financial and institutional arrangements. The limited resources of local governments to meet the wastewater management needs of highly fluctuating seasonal populations are the major constraint. The provision of central or regional wastewater treatment systems, even with federal and state assistance, may prove to be beyond the financial capacity of some of the barrier island communities given the existing tax base and presently incurred debt service obligations. A decentralized approach to wastewater management which emphasizes the continued use of on-site and small community systems poses significantly less financial risk to local governments and will be relatively easy to implement.

Based on the expected federal 201 program funding for the next four years, the highest ranked community, Atlantic Beach (81), would not expect funding until 1986 or later depending on availability of funds. The remaining communities are considerably lower on the North Carolina Department of Environmental Management's list. However, a special situation exists where innovative and alternative wastewater management systems are proposed for use in a 201 study area. The federal government has designated four percent of the total amount of 201 funding for use on innovative and alternative systems. Therefore, if a 201 Plan had a low ranking and had completed all information requirements, and in addition was an innovative or alternative system, the project could be funded before higher priority conventional sewer projects. Communities that can demonstrate innovative solutions to wastewater treatment problems would therefore be more likely to obtain 201 project funding if and when further grants are approved. Such decisions will be made by the North Carolina Division of Environmental Management.

Implementation of the EIS Strategy involves updating the draft 201 Plans. Thereafter, the state would review and resolve issues and certify the 201 Plan. A Finding of No Significant Impact is prepared whenever this is found to be the case. Each 201 would then be placed on the state's priority list for funding.

The update program will address population, land use, flows, system selection, and institutional and financial arrangements. In several 201 planning areas the selected alternative could be a combination of on-site soil absorption systems and small community systems. In large part, this scenario represents a continuation of present practices and as such poses no barriers to implementation. The present mix of on-site and small community systems could shift toward a higher percentage of small community systems to serve an increased density of development.

Financial arrangements should not present as great a potential barrier to implementation under the EIS Strategy as is the case under the 201 Strategy. Total project costs should be smaller, and some of the systems may be eligible for innovative and alternative system 85 percent funding of grant-eligible portions. Again, however, each community's place on the state priority list could cause delays in implementation.

A condition of receiving 201 construction grant money would be the requirement that local governments establish public on-site and small community wastewater management agencies where such systems are selected. Such agencies have been established elsewhere in the country and may offer benefits. The Clean Water Act, EPA regulations and program requirements memoranda (particularly PRM #79-8) require that applicants for construction grant money to fund such systems

- Establish a comprehensive program for regulation and inspection of on-site systems that will include periodic testing of existing potable water wells and, where a substantial number of on-site systems exists, more extensive monitoring of aquifers;
- Certify that a public body will be responsible for the proper installation, operation, and maintenance of the funded systems; and
- Obtain assurance of unlimited access to each individual system at all reasonable times for inspection, monitoring, construction, maintenance, rehabilitation, and replacement.

Several months would likely be required to establish such agencies, but this task does not represent a barrier to implementation. The Alternatives Evaluation Task Report contains case studies describing the activities of several of these existing agencies which could serve as models for barrier island communities, if desired.

d. Timeliness

The amount of time required to implement a strategy could be an important factor in determining the feasibility of various approaches to wastewater management. Table II.12 lists the activities required to implement the EIS Strategy.

e. Reliability

Reliability is a measurement of the ability of a component or system to perform its designated function without failure. With respect to wastewater treatment systems, reliability would be related to the ability of a system to maintain a specified water quality standard. To discuss and compare reliability, three areas will be defined that can affect effluent quality:

- Mechanical reliability
- Process reliability
- Operator reliability.

Table II.12 EIS Strategy: Program Activities.

---

1. Draft EIS is published. Applicant may proceed with the understanding that comments received after publication of the Draft EIS may alter the selected strategy.
2. Applicant works with EPA and state agencies to implement the EIS Strategy procedures.
3. Communities work with members of the General Assembly to pass any enabling legislation needed to set up on-site wastewater management districts, if districts are desired.
4. State prepares certification and Finding of No Significant Impact (FNSI).
5. EPA reviews 201 Plan and FNSI and approves FNSI.
6. Interlocal agreements are signed and management agency, if desired, is put in place.
7. 30-day comment period on FNSI is provided.
8. If no negative comments are received, Step 2 and Step 3 monies are granted subject to available funding and the applicant's position on the state's priority list.
9. Application to state agencies for permits.
10. Local share capital funds are raised after approval by the North Carolina Local Government Commission.
11. Design and construction begin.

Source: EPA, Region IV. NEPA Compliance Section. 1981.

Activity 1. The applicant could start activities three to six months before the publication of the Final EIS and thus might be ready to apply to the state for certification relatively rapidly. Identification of financial and institutional arrangements could be relatively rapid if the capital costs are smaller than those of the 201 Plans and only one political jurisdiction is involved.

Activity 7. Because the selected alternatives will be mainly innovative and alternative systems and the grant requests relatively small, it is possible that funding will be more rapid than under the 201 Strategy.

Activity 9. The local share should be a smaller amount than that required by the 201 Strategy; hence a bond issue referendum might be expected to meet with less voter resistance.

Mechanical reliability deals with mechanical, electrical and fluids handling systems. Generally speaking, the fewer the number and the lower the complexity of components in a plant, the higher the mechanical reliability of that system.

Process reliability deals with the ability of the physical, chemical or biological systems in a treatment plant to adjust to or recover from stressful situations. These situations include hydraulic overload, flooding or wide variations in organic loading. While it is possible to design a wastewater treatment plant to accommodate anticipated stress situations, on a dollar-for-dollar basis physical processes are the most reliable. Biological processes tend to be more sensitive to and take longer to recover from stress situations, but are generally lower priced than chemical processes.

Operator reliability impacts the previous two areas since poor operation can promote mechanical failure and can reduce the ability of any process train to accommodate stresses. Procedures developed in this EIS emphasize the importance of proper operations and the need for adequate staffing and operator training. The level of operator training is directly related to the size and complexity of the wastewater treatment system.

Implementation of the EIS Strategy is expected to result in the installation of a mixture of on-site and small community wastewater management systems. On-site systems continue to be the primary management approach in low-density residential development areas. In higher density residential and commercial areas, small community systems will most likely be installed.

Because of their simplicity, the mechanical reliability of these systems is considered high, although they may be susceptible to storm damage during hurricane-type events. Process reliability is also relatively high since many of the systems are mechanically or chemically oriented, and the biological systems are easy to rejuvenate (such as in septic tank systems). Operator reliability historically has been poor for these systems and can only be improved through a centrally-administered operation and maintenance program where economy of scale can justify the cost of certified operators and sufficient manpower and equipment to maintain a large number of decentralized units. A centralized operations and maintenance program will also have the facilities and expertise to quickly repair or replace stormdamaged units.

B. 201 Strategy

The 201 Strategy consists of implementing the draft 201 Plans largely in the form in which they were submitted to EPA for review. Certain aspects, such as cost data, will need updating. Therefore, the following sections of this chapter describe the provisions of the draft 201 Plans and assess their impacts with regard to development potential, local government and household financial burden, implementability and timeliness.

1. Description of Individual 201 Plans

In each case, central or regional wastewater management systems were proposed for barrier island communities. Only in the Hatteras Island Plan was such a solution judged unfeasible, and the 201 consultants recommended that such a system be re-examined around 1990.

a. Southwestern Brunswick County 201 Plan

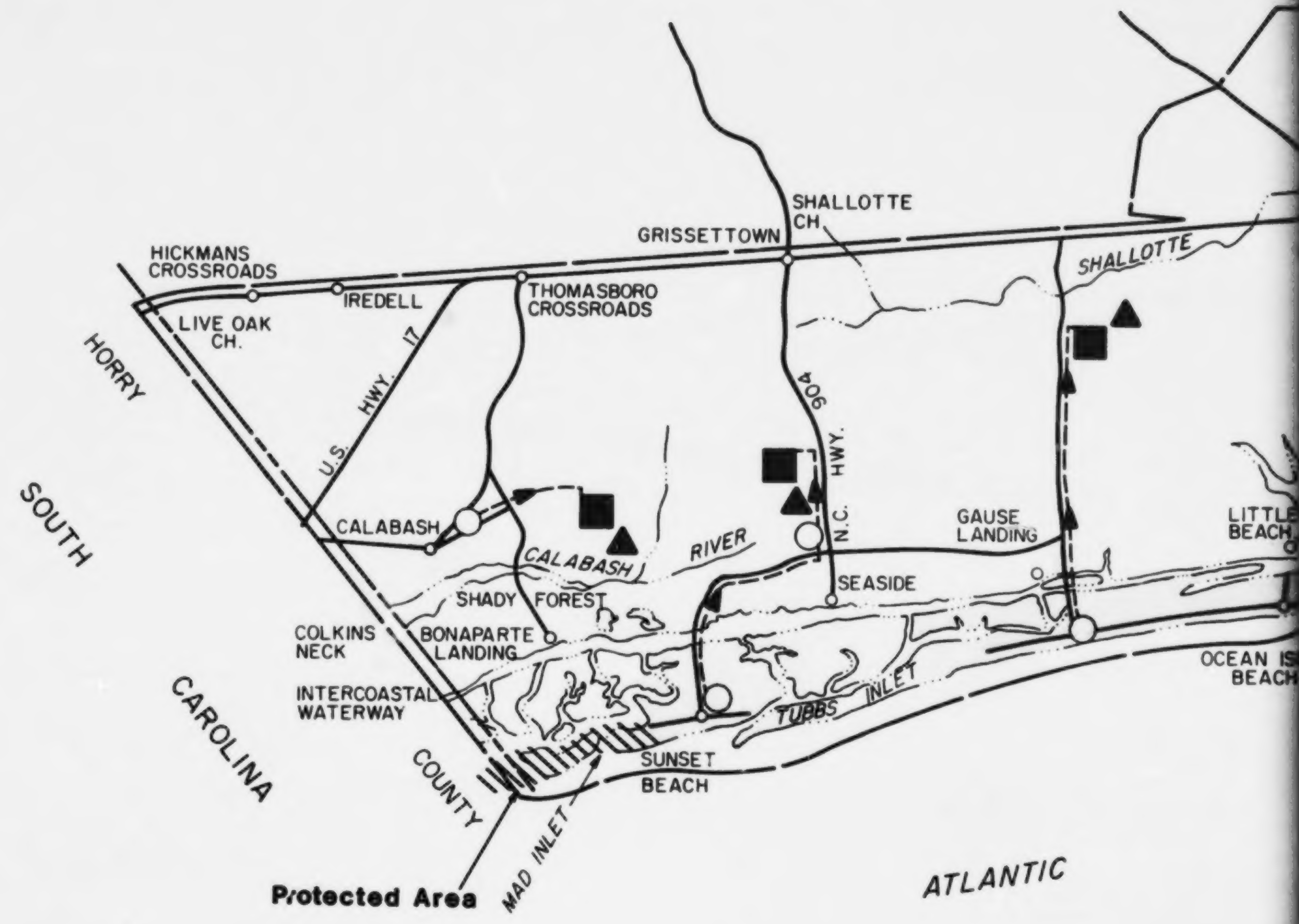
The proposed alternative includes five separate collection/interceptor systems, treatment plants, lagoon systems, and sites for land application by a solid set spray irrigation system. Figure II.22 is a map showing the location of these systems. Each town's collected wastewater flows will flow to the town's own main pump station. From there they will flow to the lagoon system which will provide secondary treatment. The lagoon system includes coarse screening facilities (prior to lagoon), a lagoon, and chlorination facilities. The lagoon effluent is chlorinated prior to land application. The 201 Plan stated that due to the nature of the treatment process, daily sludge handling and disposal will not be required. Generally, the sites selected for land application are located in rural areas that are forested and/or undeveloped land.

Costs for the three barrier island systems are presented in Table II.13. These costs are those presented in the draft 201 Plan prepared in 1979 and have not been updated. These figures do not include the cost for a collection system.

Table II.13. Estimated Project Capital Costs and Annual Local Costs for Southwestern Brunswick County.

	Ocean Isle Beach	Holden Beach	Sunset Beach
Pump Station	$118,897	$118,987	$95,266
Force Main	154,277	268,931	132,164
Pretreatment	453,162	572,621	--
Land Application	282,645	285,897	478,693
Land Acquisition	110,500	116,500	55,500
Total	$1,119,481	$1,362,936	$761,623
Local Annual O&M	$30,886	$30,917	$25,144
Local Annual Debt Service	8,225	10,305	3,824
Total Local Annual Cost	$39,141	$41,222	$28,968

Source: Pierson and Whitman, Inc. 1979. Southwest Brunswick County 201 Facilities Plan.


SHALLOTTE CH
GRISSETTOWN
HICKMANS CROSSROADS
IREDELL
THOMASBORO CROSSROADS
LIVE OAK CH.
SHALLOTTE
HORRY
U.S. HWY. 17
N.C. HWY. 904
SOUTH
CALABASH
CALABASH RIVER
GAUSE LANDING
LITTLE BEACH
SHADY FOREST
SEASIDE
COLKINS NECK
BONAPARTE LANDING
OCEAN IS BEACH
INTERCOASTAL WATERWAY
TUBBS INLET
CAROLINA
COUNTY
SUNSET BEACH
MAD INLET
Protected Area
ATLANTIC

LEGEND

▭ SEWAGE SERVICE DISTRICT

— — 201 FACILITIES PLANNING AREA BOUNDARY

- - - - MAJOR FORCE MAIN

■ WASTEWATER TREATMENT FACILITY

○ PUMPING STATION

▲ LAND APPLICATION SITES

BARRIER ISLANDS E.I.S.

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

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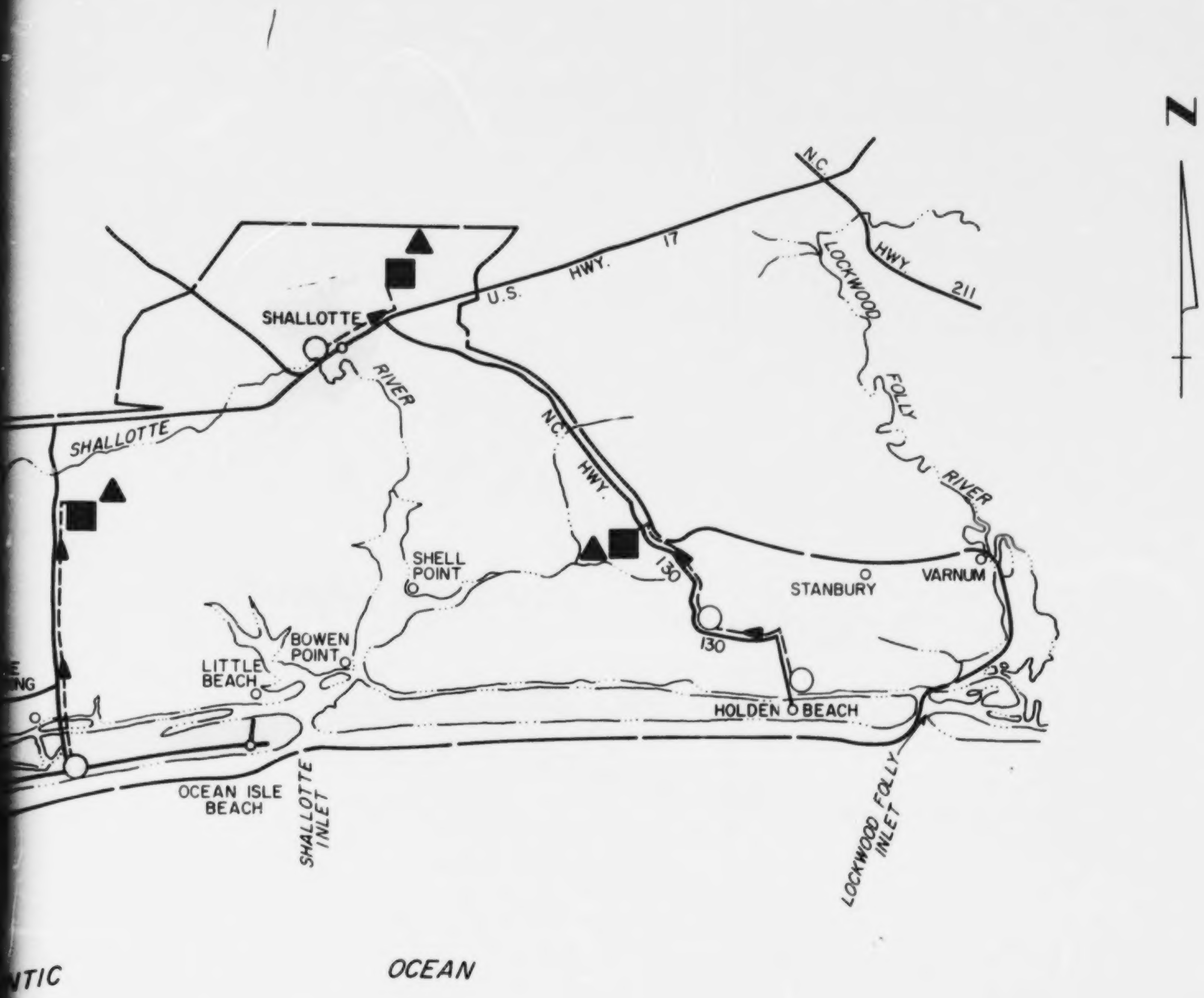
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N.C.
U.S. HWY. 17
HWY. 211
LOCKWOOD FOLLY RIVER
SHALLOTTE
SHALLOTTE RIVER
N.C. HWY. 130
130
SHELL POINT
STANBURY
VARNUM
BOWEN POINT
LITTLE BEACH
HOLDEN BEACH
58
OCEAN ISLE BEACH
SHALLOTTE INLET
LOCKWOOD FOLLY INLET
NTIC
OCEAN

Figure II.22
REGIONAL ALTERNATIVE PLAN
FIVE LOCAL TREATMENT FACILITIES WITH
LAND APPLICATION SITES FOR
SPRAY IRRIGATION OF EFFLUENT

201 FACILITIES PLANNING AREA
SOUTHWEST BRUNSWICK COUNTY

E.I.S.

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

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SCALE IN MILES

b. Southeastern Brunswick County 201 Plan

The 201 Plan for the Southeastern Brunswick County planning area proposed extending the existing collection system which presently serves only the town of Southport to include parts of Oak Island and some rural areas outside of Southport's boundaries. The new systems proposed will include the Oak Island communities of Long Beach, Yaupon Beach, Caswell Beach, and portions of unincorporated rural areas in Brunswick County. The regional treatment facilities would be located on a 10.1 ha (25 ac) site near Southport and would provide secondary treatment for a design flow of 7845.3 m^3/d (2.07 mgd). The location of these facilities is shown in Figure II.23.

The collection/interceptor system is proposed to service areas that were identified as having a need based on projected development for 1990. The interceptor system that would transport the collected wastewater flows would include force mains with a system of lift stations and pump stations.

The proposed treatment facilities would consist of an oxidation ditch treatment process that provides secondary treatment for a design flow of 7,845.3 m^3/d (2.07 mgd). The existing secondary treatment facilities serving the town of Southport would be abandoned. The treated effluent would then be discharged to the Cape Fear River.

Costs for the proposed treatment project as indicated in the 201 Plan are presented in Table II.14.

Table II.14. Estimated Project Capital Costs and Annual Local Costs for Southeastern Brunswick County.

Collection System	$3,752,000
Transmission System	9,985,000
Treatment System	5,763,000
Total Capital Cost	$19,500,000
Local Annual Debt Service	$1,410,000
Local Annual O & M	$314,000
Total Local Annual Cost	$1,724,000

*Total annual debt service costs is for the total project and does not reflect federal and state grants covering 87.5 percent of eligible costs.

Source: Consoer, Townsend and Associates. 1978. Southeastern Brunswick County Facilities Plan.

c. Topsail/Surf City 201 Plan

The preliminary design of the system consists of a series of gravity sewer subsystems which would run in a linear fashion along the oceanfront. The sewer systems would have a complementary interceptor system consisting of

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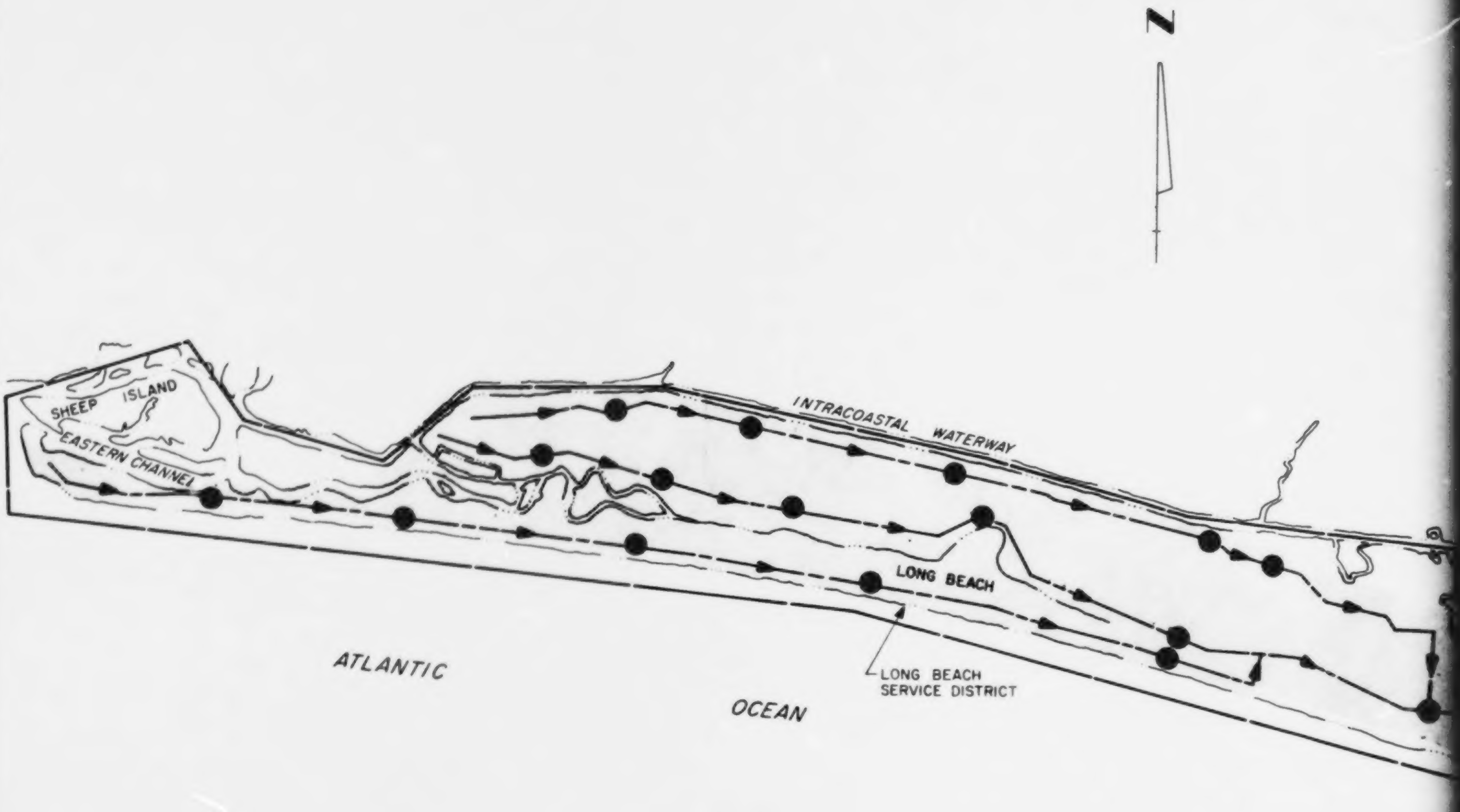
N
SHEEP ISLAND
EASTERN CHANNEL
INTRACOASTAL WATERWAY
LONG BEACH
LONG BEACH SERVICE DISTRICT
ATLANTIC
OCEAN
YA
SE

LEGEND

- —— 201 FACILITIES PLANNING AREA BOUNDARY
- - - - MAJOR FORCE MAIN
- — - GRAVITY LINE
- ■ WASTEWATER TREATMENT FACILITY
- ● LIFT STATION
- ○ PUMPING STATION
- ▭ SEWAGE SERVICE DISTRICT

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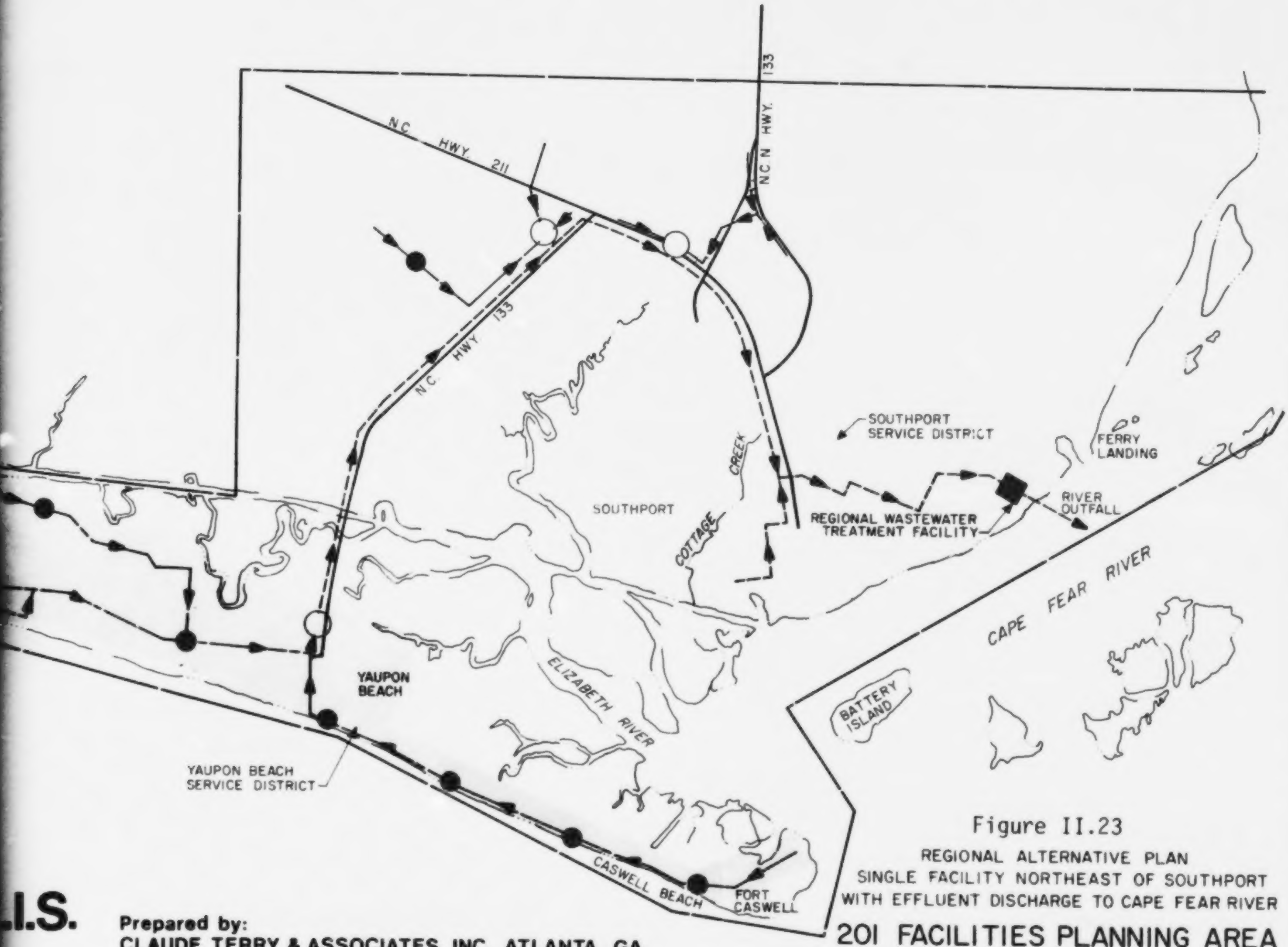
N.C. HWY. 211
N.C.N HWY. 133
N.C. HWY. 133
SOUTHPORT SERVICE DISTRICT
FERRY LANDING
SOUTHPORT
COTTAGE CREEK
REGIONAL WASTEWATER TREATMENT FACILITY
RIVER OUTFALL
CAPE FEAR RIVER
BATTERY ISLAND
YAUPON BEACH
ELIZABETH RIVER
YAUPON BEACH SERVICE DISTRICT
CASWELL BEACH
FORT CASWELL

Figure II.23

REGIONAL ALTERNATIVE PLAN
SINGLE FACILITY NORTHEAST OF SOUTHPORT
WITH EFFLUENT DISCHARGE TO CAPE FEAR RIVER

I.S.

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

201 FACILITIES PLANNING AREA SOUTHEASTERN BRUNSWICK COUNTY

4,000
0
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SCALE IN FEET

pump stations and force mains necessary to pump the collected wastewaters to the treatment facilities west of Holly Ridge. The interceptor system would include the construction of a subaqueous force main to serve as a waterway crossing to transport flows from Topsail Island to the mainland. The installation of this crossing would be located adjacent to the existing highway (N.C. Route 50-210) bridge at Surf City. Figure II.24 is a map showing the location of these facilities.

The collected wastewater flows would be treated by a newly constructed stabilization lagoon treatment system on a site at Camp Davis west of Holly Ridge which is outside the planning area's borders. These facilities are designed to handle a flow of 8,717.0 m^3/d (2.3 mgd), and all sludge would be collected and disposed at a sanitary landfill. The treated effluent would then be disposed of by land application via a solid set spray irrigation system on a pine forest site near the treatment facilities. The 101.25 ha (250 ac) site is located in an isolated rural area and will be leased from the International Paper Company, Inc.

Costs developed in 1979 for implementing the proposed 201 Plan are presented in Table II.15. Costs of collection systems are not included.

Table II.15. Estimated Project Capital Costs and Annual Local Costs for Topsail/Surf City.

	Total Cost	Federal Cost	State Cost	Topsail	Surf City	West Onslow	Pender County
Design	$724,494	$592,905	$28,645	$27,383	$30,986	$38,501	$6,074
Construction	11,777,009	9,634,200	629,119	403,642	455,621	566,120	89,307
Other	1,560,148	1,130,415	71,260	95,354	107,901	134,069	21,150
Total	$14,061,651	$11,357,520	$729,024	$525,370	$594,508	$738,690	$116,531
Local Annual Debt Service				$31,145	$35,242	$43,790	$6,908
Local Annual O & M				68,805	77,858	96,741	15,261
Total Local Annual Cost				$99,950	$113,100	$140,531	$22,169

Source: Henry Von Oesen and Associates. 1980. Topsail-Surf City 201 Facilities Plan.

The local share of the project costs are expected to be supported by general obligation bonds. The general obligation bonds and O&M costs may be repaid from revenues derived from a system of sewer user charges. Final project costs based on actual bids will determine the amount of bonds to be issued. The actual number of users at the time of project completion will determine the actual user charges. These charges will be prorated based on peak seasonal populations in each local jurisdiction. The estimated average monthly sewer user charge ranges from $11.49 to $14.28. The charges do not include costs of collection systems.

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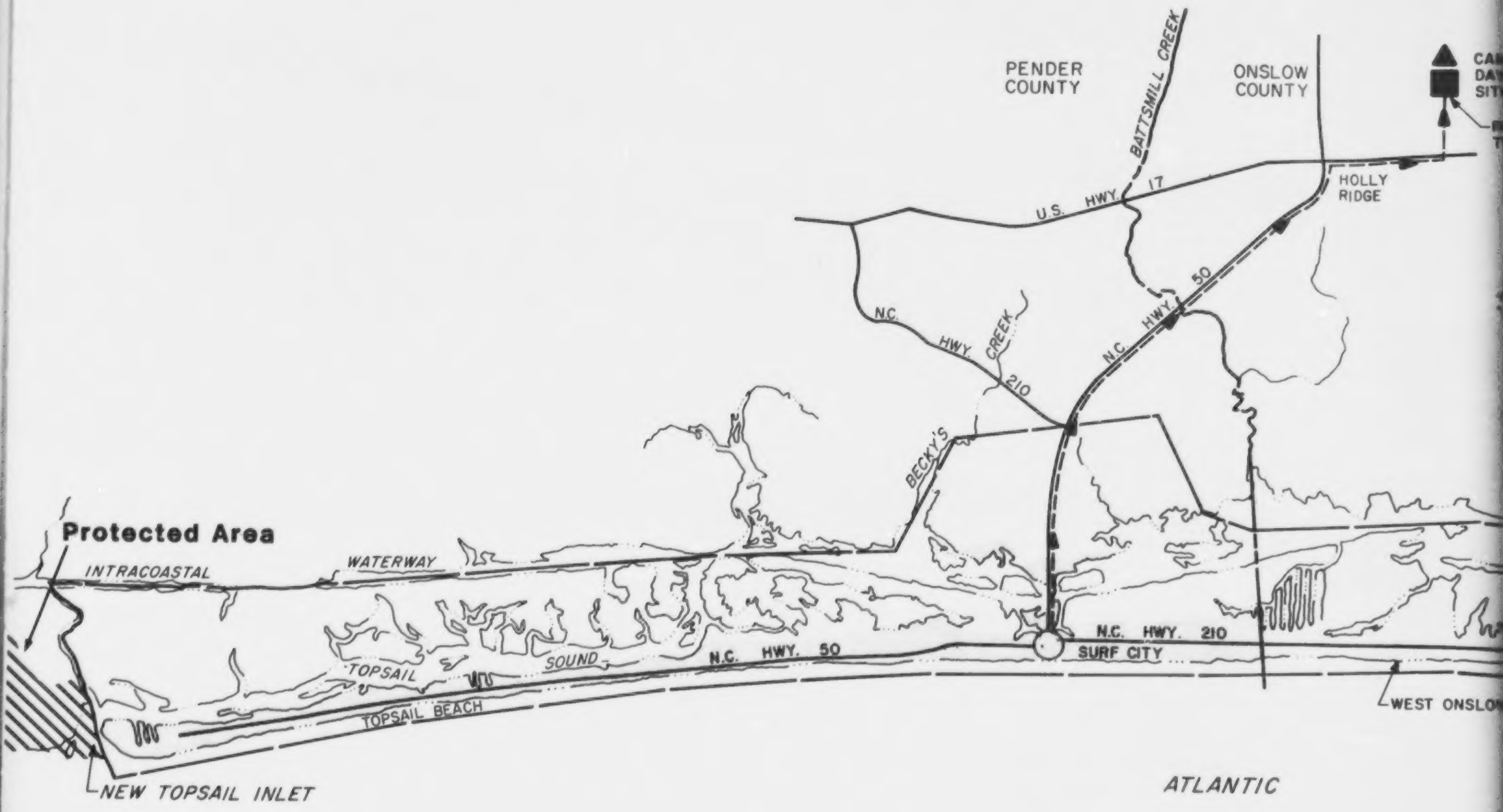
PENDER COUNTY
BATTSMILL CREEK
ONSLOW COUNTY
U.S. HWY. 17
HOLLY RIDGE
N.C. HWY. 50
N.C. HWY. 210
CREEK
BECKY'S
Protected Area
INTRACOASTAL
WATERWAY
TOPSAIL
SOUND
N.C. HWY. 50
N.C. HWY. 210
SURF CITY
TOPSAIL BEACH
NEW TOPSAIL INLET
ATLANTIC
WEST ONSLOW

LEGEND

- —— 201 FACILITIES PLANNING AREA
- - - - MAJOR FORCE MAIN
- ■ WASTEWATER TREATMENT FACILITY
- ○ PUMPING STATION
- ▲ LAND APPLICATION
- ☐ SEWAGE SERVICE DISTRICT

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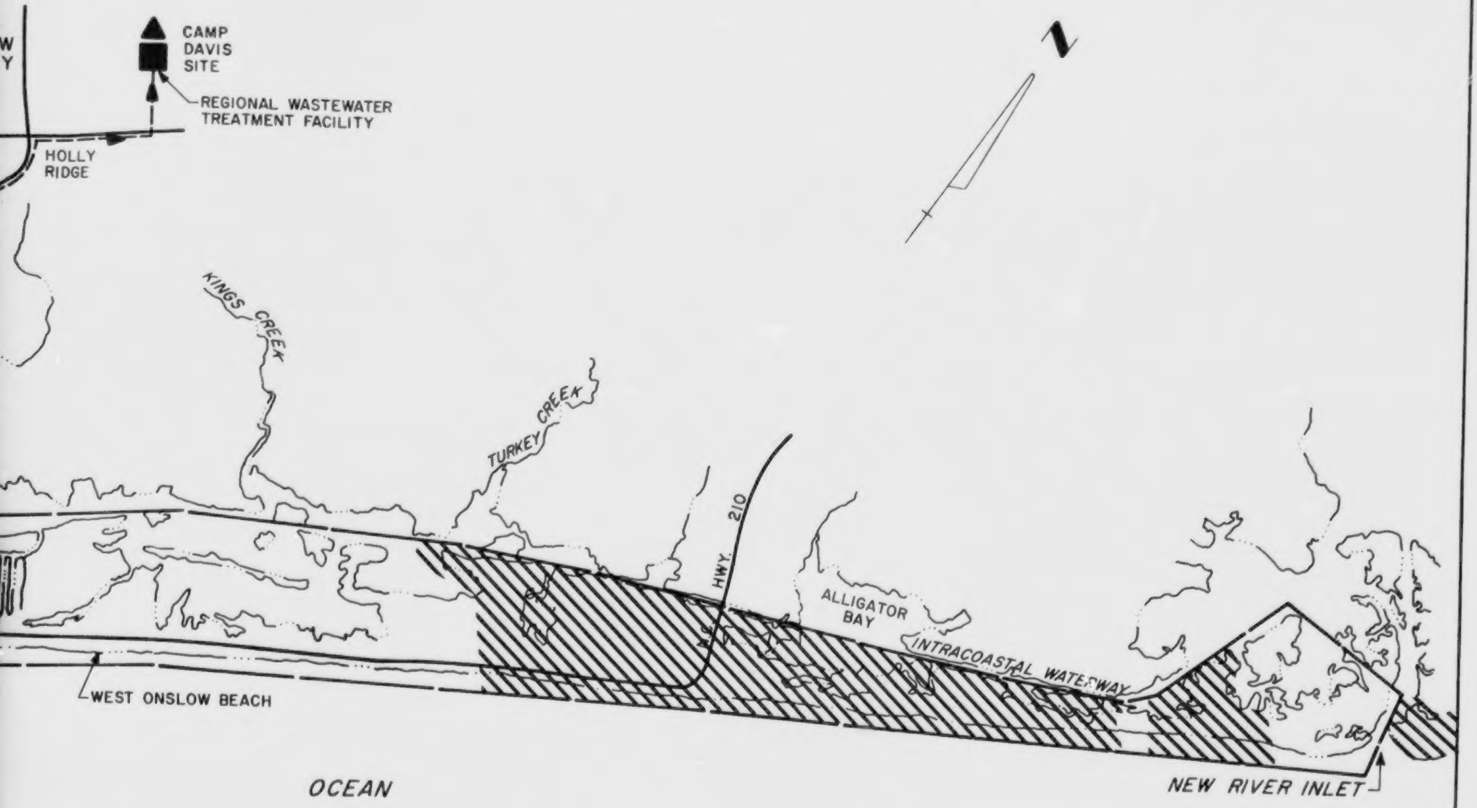
W
Y
CAMP
DAVIS
SITE
REGIONAL WASTEWATER
TREATMENT FACILITY
HOLLY
RIDGE
KINGS CREEK
TURKEY CREEK
HWY. 210
ALLIGATOR
BAY
INTRACOASTAL WATERWAY
WEST ONSLOW BEACH
OCEAN
NEW RIVER INLET

.S.

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

Figure II.24

REGIONAL ALTERNATIVE PLAN
SINGLE FACILITY LOCATED AT CAMP DAVIS SITE
WITH LAND APPLICATION OF EFFLUENT

201 FACILITIES PLANNING AREA
TOPSAIL-SURF CITY

6,000 0 6,000 12,000
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The participating local units of government have agreed that some form of regional management agency is the best method for operating the proposed wastewater treatment system. The agency structure has not been delineated, but various alternatives are under consideration. The 201 Plan identifies the formation of this agency and the enactment of a lease agreement with the International Paper Company for use of the land application site as the two most important steps in the implementation process.

A schedule of implementation steps is included in the plan as well as a listing of permits that are required for project implementation. In addition, the required operations and maintenance personnel specifications and operation manual are referenced.

d. Carteret County 201 Plan

On the mainland, Beaufort and Moorhead City will be served by centralized wastewater treatment systems. A third facility would be located at Pine Knoll Shores on Bogue Banks. The location of these systems is shown on Figure II.25.

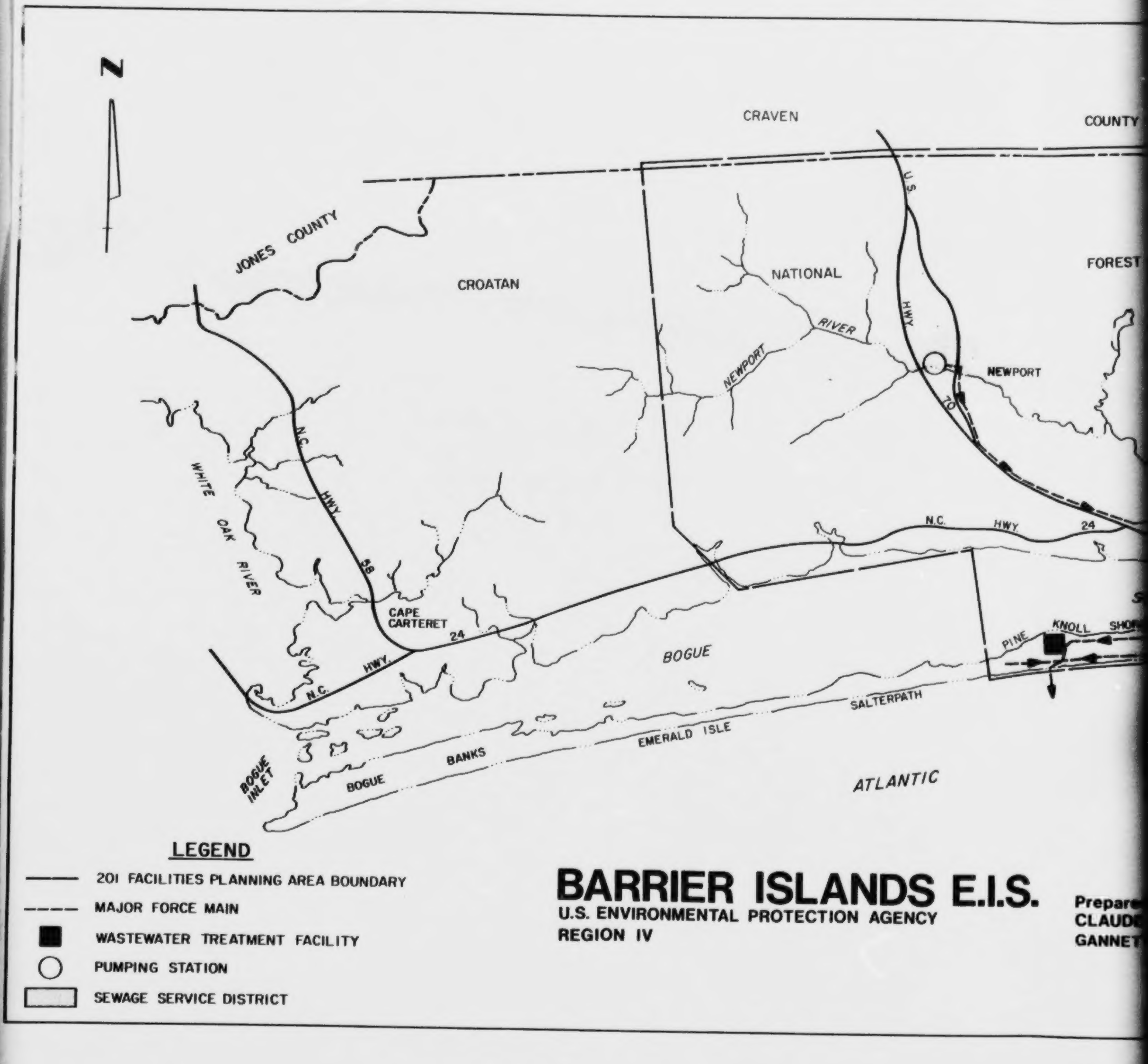
The service areas that would utilize the proposed treatment facilities at Pine Knoll Shores are a part of East Bogue Banks and include the communities of Atlantic Beach and Pine Knoll Shores plus all the newly annexed areas adjacent to Atlantic Beach. The Atlantic Beach collection system would be a conventional gravity sewer system consisting of gravity sewer mains, manholes, laterals, service clean-outs, lift stations, and force mains. All flows would then be directed to a central lift station which would pump the collected wastewater via a force main to the 3,865.8 m^3/d (1.02 mgd) regional wastewater treatment works at Pine Knoll Shores. The Pine Knoll Shores collection system is proposed to be a pressure sewer system based on a grinder pump alternative.

Effluent disposal would be via an ocean outfall that is proposed to extend one mile offshore into the Atlantic Ocean. The 201 Plan calls for the completion of a marine site survey in order to define the exact location, length, etc. of the outfall and to provide specific design data about the pipeline and its diffuser section.

Project costs as presented in the draft 201 Plan are presented in Table II.16 for Atlantic Beach and Pine Knoll Shores.

Local funds for the project are to be collected solely through a user charge system. Although the plan mentions that other revenue sources may be used, the projected costs do not warrant issuing general obligation bonds. Local monthly user charges are estimated at $8.31 for Atlantic Beach and $11.09 for Pine Knoll Shores. These figures do not include the cost of constructing an ocean outfall.

The 201 Plan investigates seven possible institutional arrangements which could serve the needs of Bogue Banks. The recommended organization is a Metropolitan Water District, chosen because future growth may make it advantageous for the MWD to control both sewer and water systems. The plan also recognizes that the governmental units must negotiate implementation agreements which would require significant time and energy from all parties to determine equitable agreements.


N
CRAVEN
COUNTY
JONES COUNTY
CROATAN
NATIONAL
FOREST
NEWPORT RIVER
NEWPORT
U.S. HWY. 70
N.C. HWY. 58
N.C. HWY. 24
WHITE OAK RIVER
CAPE CARTERET
24
N.C. HWY.
BOGUE
PINE KNOLL SHORES
SALTERPATH
EMERALD ISLE
BOGUE BANKS
BOGUE INLET
ATLANTIC
LEGEND
201 FACILITIES PLANNING AREA BOUNDARY
MAJOR FORCE MAIN
■ WASTEWATER TREATMENT FACILITY
○ PUMPING STATION
▭ SEWAGE SERVICE DISTRICT

BARRIER ISLANDS E.I.S.

U.S. ENVIRONMENTAL PROTECTION AGENCY
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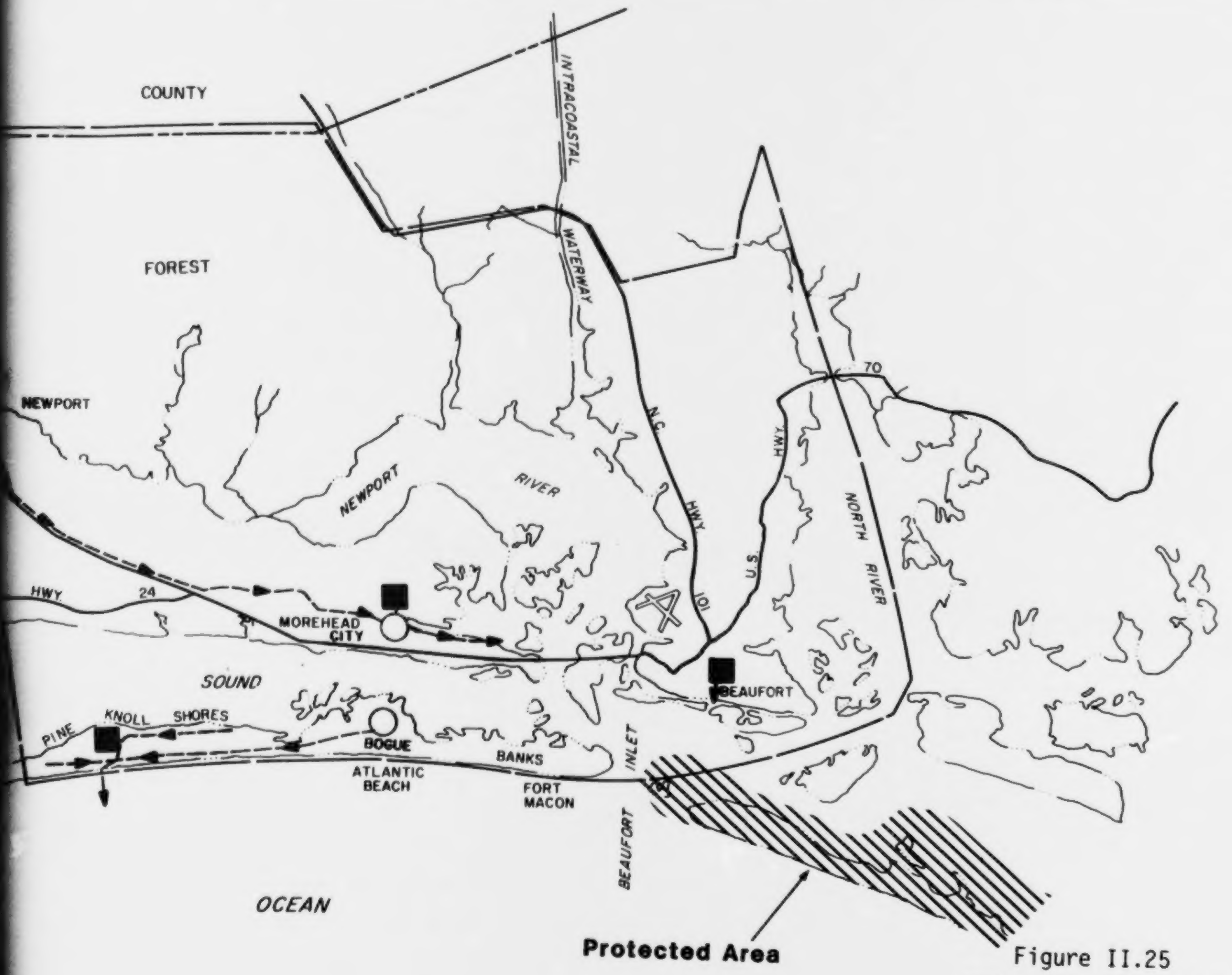

COUNTY
FOREST
INTRACOASTAL WATERWAY
NEWPORT
N.C. HWY 101
70
U.S. HWY
NORTH RIVER
NEWPORT RIVER
HWY 24
MOREHEAD CITY
BEAUFORT
SOUND
PINE KNOLL SHORES
BOGUE
BANKS
ATLANTIC BEACH
FORT MACON
INLET
BEAUFORT
OCEAN
Protected Area

Figure II.25

REGIONAL ALTERNATIVE PLAN
3 SEPARATE TREATMENT FACILITIES WITH
EFFLUENT DISCHARGE TO ATLANTIC OCEAN,
TAYLORS CREEK, AND NEWPORT RIVER

201 FACILITIES PLANNING AREA
CARTERET COUNTY COMPLEX

1 0 1 2 3 4
SCALE IN MILES

.I.S.

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

Table II.16 Estimated Project Capital Costs and Annual Local Costs for Bogue Banks in Carteret County.

	Atlantic Beach	Local Share	Pine Knoll Shores	Local Share
Ocean Outfall Study	$37,500	$ 5,016	$ 37,500	$ 5,016
Treatment Facility	1,420,205	189,953	1,420,205	189,953
Pumping Station/ Force main	824,057	110,217	175,910	23,527
Collection System	2,480,590	331,778	1,644,687	131,986
Total	$4,762,352	$636,964	$3,278,302	$350,482
Local Annual Debt Service		$41,465		$17,081
Local Annual O&M		97,409		78,079
Total Local Annual Cost		$138,874		$95,160

Source: William F. Freeman Associates and Henry Von Oesen and Associates. 1979. Carteret County Complex 201 Facilities Plan.

A description of the general implementation steps and a schedule of events are presented to clarify future responsibilities for completing the treatment facility. In addition, staffing requirements, organizational structure and operations and maintenance needs are detailed for each facility component.

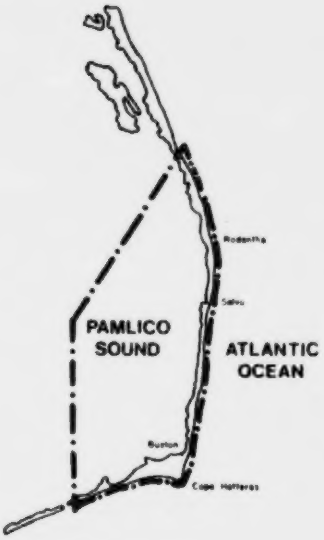
Pine Knoll Shores has not agreed to participate in the draft 201 Plan as described. This will necessitate a modification of the original plan either to include Pine Knoll Shores in an alternative which they approve or prepare another plan which does not include them.

e. Hatteras Island 201 Plan

The wastewater planning area was subdivided into two service districts. The first coincides with the public water supply district boundaries, the Cape Hatteras Water Association (CHWA) service area, comprising the villages of Avon, Buxton, Frisco and Hatteras. The second service area contains the villages of Rodanthe, Waves and Salvo. The location of these systems is shown in Figure II.26.

Three similar structural alternatives were considered for the CHWA area and two for the Rodanthe/Waves/Salvo (RWS) area. Wastewater will be collected and transported by conventional gravity flow sewers and pump stations. Treatment included grit removal, equalization, activated sludge treatment, filtration and disinfection. Sludge would be aerobically digested and dewatered mechanically in the CHWA area and dewatered on drying beds in the RWS area. Dried sludge would then be transported to the county landfill on Roanoke Island. Effluent would be disposed by rotary distributors.

The least costly alternative for the CHWA area involved a regional system with treatment and disposal at Avon in Buxton Woods. The least costly alternative for the RWS area was a regional system with treatment and disposal at


Rodanthe
Salvo
PAMLICO SOUND
ATLANTIC OCEAN
Buxton
Cape Hatteras

LOCATION MAP

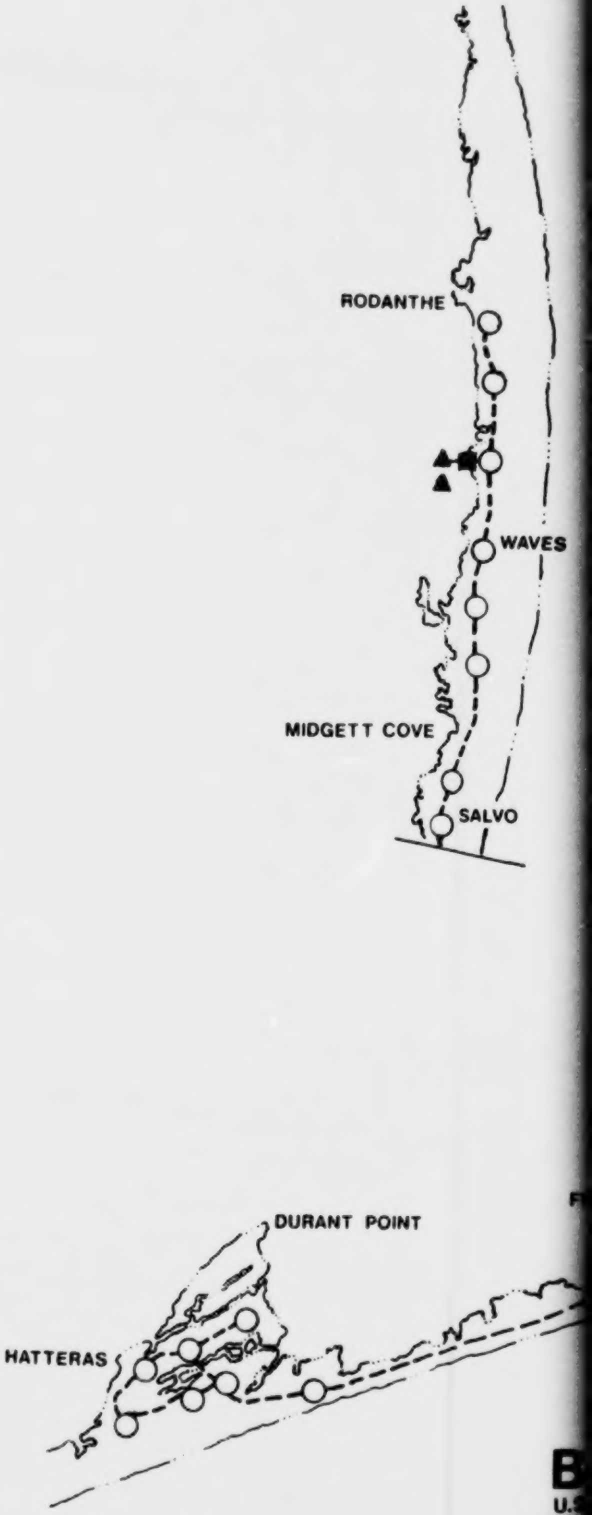

RODANTHE
WAVES
MIDGETT COVE
SALVO
DURANT POINT
HATTERAS

Figure II.26

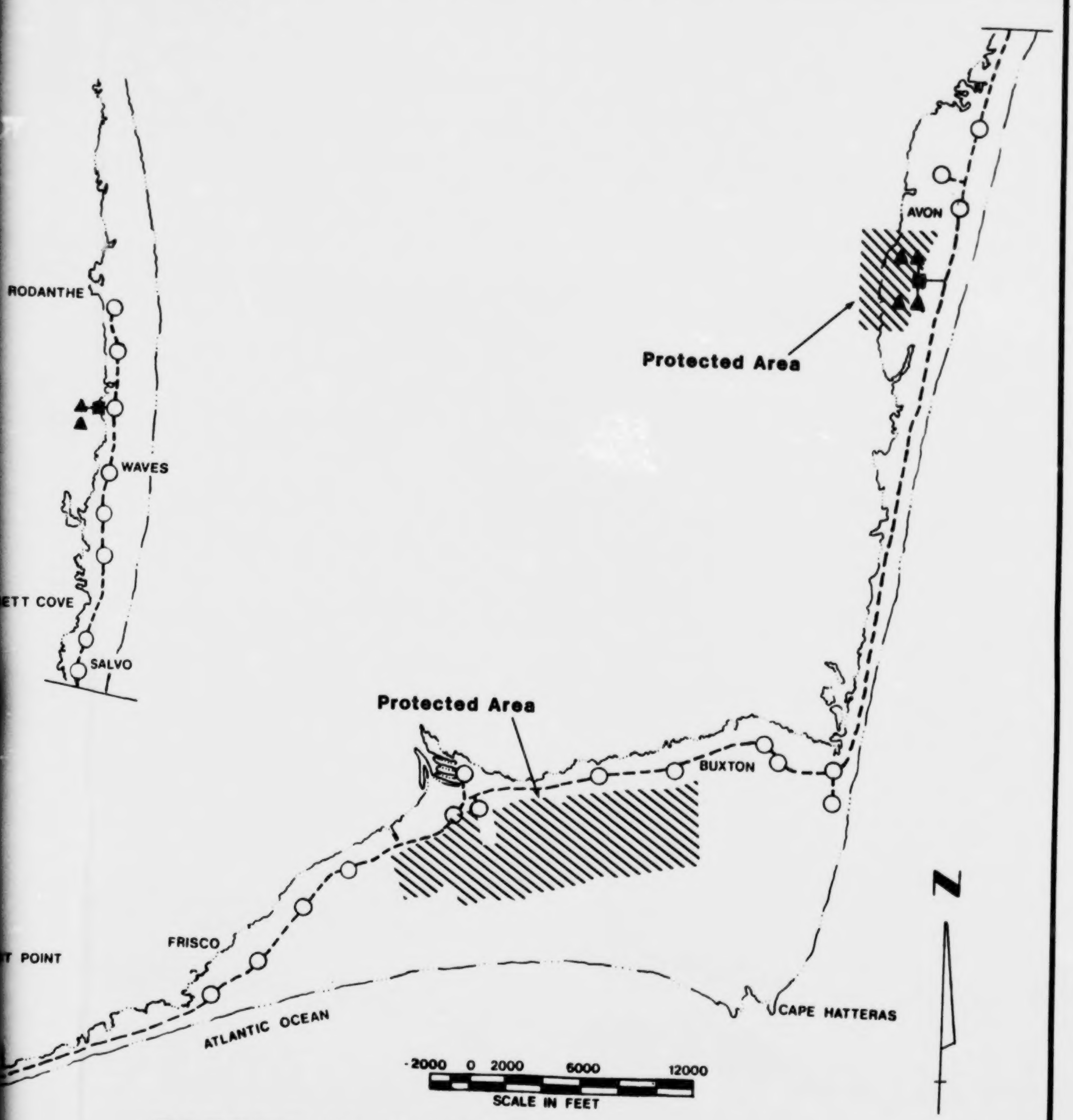
201 FACILITIES PLANNING AREA
HATTERAS ISLAND

NOTE: Not All Pumping Stations Are Shown

LEGEND

- - - - MAJOR FORCE MAIN
■ WASTEWATER TREATMENT FACILITY
○ PUMPING STATION
▲ LAND APPLICATION

B


RODANTHE
WAVES
ETT COVE
SALVO
AVON
Protected Area
Protected Area
BUXTON
FRISCO
T POINT
ATLANTIC OCEAN
CAPE HATTERAS
-2000 0 2000 6000 12000
SCALE IN FEET
N

BARRIER ISLANDS E.I.S.

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

a site between Rodanthe and Waves. Project costs as presented in the draft 201 Plan are shown in Table II.17.

The 201 consultants have recommended that no action be taken on the proposed structural alternatives because user charges are too high to be affordable. Even with additional collector system grants from FmHA, annual user charges for a typical household would approach $402.48 for the CHWA area and $336.00 for the RWS area.

Table II.17. Estimated Project Capital Costs and Annual Local Costs for Hatteras Island.

	Avon/Buxton/ Frisco/Hatteras	Rodanthe/ Waves/Salvo
Interceptors & Collectors		
Capital Cost (Initial)	$21,478,000	$5,060,000
Avg. Annual O&M	134,000	29,000
Present Worth	19,579,000	4,584,000
Treatment Facility		
Capital Cost (Initial)	6,957,000	2,572,000
Avg. Annual O&M	208,000	117,000
Present Worth	8,373,000	3,731,000
Total Present Worth	27,544,000	8,315,000
Total Capital Costs	28,285,000	7,632,000
EPA Share	11,347,500	3,375,000
State Share	1,891,250	562,500
Local Share	15,046,250	3,694,500
Annual Local Cost	1,244,000	276,000
Typical Household Annual User Charge	685	600

Source: Moore, Gardner & Associates, Inc. October 1981. Hatteras Island 201 Wastewater Facilities Plan.

f. Dare Beaches 201 Plan

The areas to be served are those with existing critical needs and/or those areas having a high priority to receive the full range of public services, according to the Dare County Coastal Area Management Act Land Use Plan. Service areas include Kill Devil Hills, Nags Head, Whalebone-South Bodie Island, Manteo and Wanchese. The collection and interceptor system would include major wastewater pumping stations with the main interceptor running along Bodie Island. A subaqueous force main, joining the main interceptor in the vicinity of Whalebone Junction, would transport the wastewater from the Roanoke Island service areas (Manteo and Wanchese). The regional treatment facilities will be located at Nags Head on land owned by the town near the existing water treatment plant. The locations of these facilities are shown in Figure II.27.

The subaqueous outfall would include a multi-port diffuser system located 1830 km (6000 ft) offshore in the Atlantic Ocean. The draft 201 Plan called for a marine site survey consistent with EPA interim regulations on ocean outfalls to be conducted in order to gather more information for proper design. The report was completed in September 1982.

Sludge would be handled by aerobic digestion and dewatering on sand drying beds. Final disposal would be at the Dare County Sanitary Landfill at Manteo by contracted hauling. Costs associated with the projected regional facility (treatment plant and interceptor lines) are presented in Table II.18. These figures do not include the cost of collector sewers and service laterals.

Table II.18. Estimated Project Capital Costs and Annual Local Costs for Dare County.

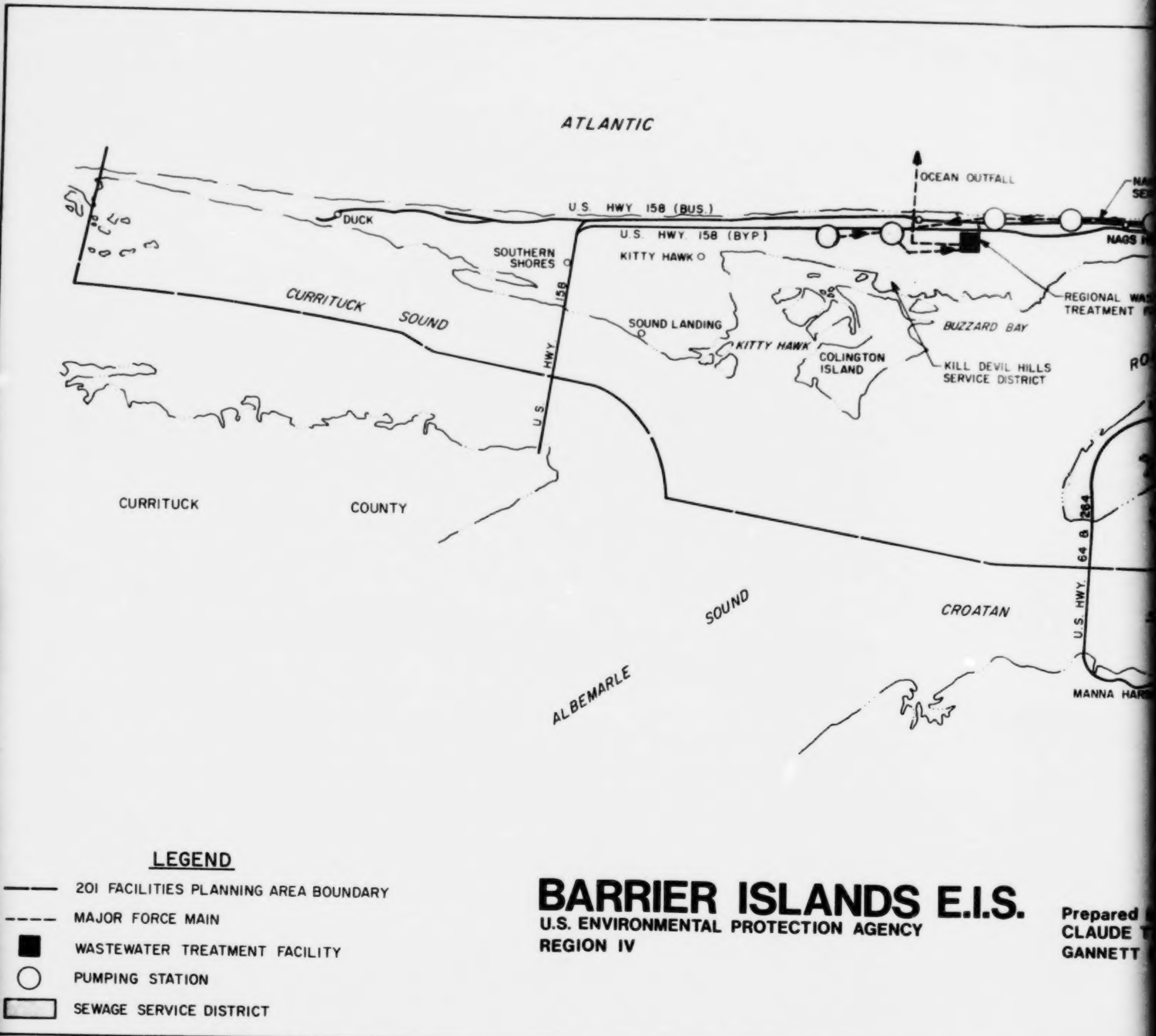
	Total	State	Local	Federal
Ocean Outfall Study	$120,000	$15,000	$15,000	$90,000
Interim Sludge Handling - Manteo	107,517		32,517	75,000
Treatment Plant	4,212,228		1,240,557	2,971,671
Regional Interceptor	6,171,815		1,826,079	4,345,736
Total	10,611,560	$15,000	$3,114,153	$7,482,407
Local Annual O & M	$239,589			
Local Annual Debt Service	183,178			
Total Local Annual Cost	$423,307			

*Includes state share of grant eligible costs - approximately $1,244,000 or 12.5 percent.

Source: Henry Von Oesen and Associates. 1977. Dare County Complex 201 Facilities Plan.

The local share of the project capital costs will have to be met by the issuance of general obligation bonds. The operations and maintenance costs of the treatment works (plants and interceptors) will be paid by a system of user charges. Two user charge systems are proposed: 1) charge each user a set rate based on proportional wasteload contribution, or 2) determine classes of use (domestic, commercial, industrial) and develop charges based on wastewater characteristics and flow. The 201 Plan recommends the latter method.

The 201 Plan for Dare Beaches recommended the most complex intergovernmental cooperation alternative of the pending plans. The county would be involved with several municipalities in establishing and operating the


ATLANTIC
OCEAN OUTFALL
NA
SE
U.S. HWY 158 (BUS.)
U.S. HWY 158 (BYP)
DUCK
SOUTHERN SHORES
KITTY HAWK
NAGS H
REGIONAL WAS
TREATMENT F
CURRITUCK SOUND
U.S. HWY 158
SOUND LANDING
KITTY HAWK
COLINGTON ISLAND
BUZZARD BAY
KILL DEVIL HILLS SERVICE DISTRICT
RO
CURRITUCK COUNTY
U.S. HWY 64 & 264
ALBEMARLE SOUND
CROATAN
MANNA HAR
LEGEND
201 FACILITIES PLANNING AREA BOUNDARY
MAJOR FORCE MAIN
WASTEWATER TREATMENT FACILITY
PUMPING STATION
SEWAGE SERVICE DISTRICT

BARRIER ISLANDS E.I.S.

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

Prepared
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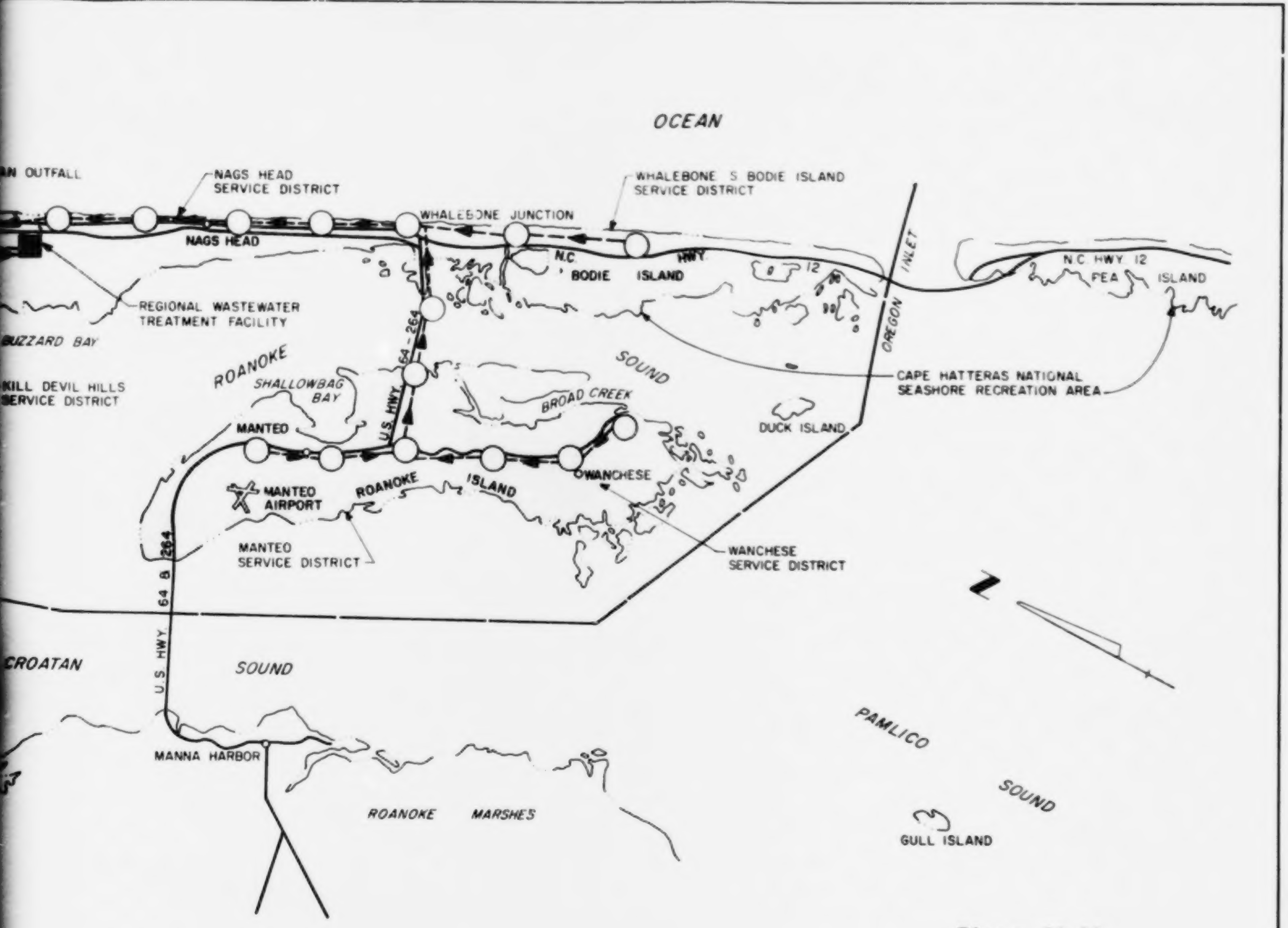
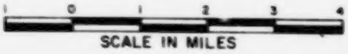

OCEAN
AN OUTFALL
NAGS HEAD SERVICE DISTRICT
WHALEBONE S BODIE ISLAND SERVICE DISTRICT
WHALEBONE JUNCTION
NAGS HEAD
N.C. BODIE ISLAND HWY. 12
OREGON INLET
N.C. HWY. 12
PEA ISLAND
REGIONAL WASTEWATER TREATMENT FACILITY
BUZZARD BAY
KILL DEVIL HILLS SERVICE DISTRICT
ROANOKE
SHALLOWBAG BAY
U.S. HWY. 64-264
SOUND
BROAD CREEK
CAPE HATTERAS NATIONAL SEASHORE RECREATION AREA
DUCK ISLAND
MANTEO
WANCHESE
MANTEO AIRPORT
ROANOKE ISLAND
MANTEO SERVICE DISTRICT
WANCHESE SERVICE DISTRICT
U.S. HWY. 64 & 264
N
CROATAN
SOUND
PAMLICO
SOUND
MANNA HARBOR
ROANOKE MARSHES
GULL ISLAND

Figure II.27

REGIONAL ALTERNATIVE PLAN
SINGLE FACILITY AT NAGS HEAD WITH EFFLUENT DISCHARGE TO ATLANTIC OCEAN

201 FACILITIES PLANNING AREA
DARE COUNTY COMPLEX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SCALE IN MILES

E.I.S.

Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC.

proposed wastewater treatment collection and treatment facilities. Therefore, the 201 Plan has identified and assessed seven different institutional management options, selecting an Interlocal Contract as the most workable and flexible mechanism for coordinating the interest of all jurisdictions. The administrative and operation and maintenance organization and procedures being established for the County's regional water supply system are well suited to expansion for this purpose.

The Plan recommends that the county be responsible for identifying the unincorporated areas where service is needed and that local collection systems to meet these requirements be constructed and installed on a carefully phased basis. The normal procedures of obtaining expressions of the desire for this service from the citizens of these selected areas would be followed. General obligation bond issues would have to be approved by public referendum, and financial arrangements for construction of the collection systems and the wastewater treatment facilities would have to be concluded. Again, it is proposed that the incorporated towns construct their own municipal sewage collection systems and the county construct the collection systems in the unincorporated areas to be serviced, with all citizens within the Community Service District supporting the local-share costs of the regional facilities (main interceptor and treatment facility) on an equitable basis through user charges.

The 201 Plan proposes a time schedule for project implementation, directly addressing the general management, financial, and design needs of the proposed collection and treatment facilities. Operations and maintenance requirements have been listed with an assessment of manpower and budgetary needs. Provisions for industrial cost recovery have also been addressed in anticipation of the ultimate development of Wanchese Seafood Industrial Harbor. Annual cost recovery from industrial sources is projected at $21,000. However, industrial cost recovery requirements were deleted by EPA, and user charges will have to be modified accordingly.

2. Impacts of the 201 Strategy

This section describes some of the impacts that can be expected if the 201 Strategy is implemented. These impacts will be compared with those of the other strategies in Chapter IV. Impacts on development potential, financial impacts, implementability, timeliness and reliability are discussed below.

a. Impacts on Development Potential

Barrier island communities will continue to develop with or without the provision of central or regional wastewater management systems. The differences between future development under the 201 Strategy and the other strategies fall into two major groupings: land use density and development in or adjacent to environmentally sensitive areas.

Under the 201 Strategy, land can be developed at any density permitted by local zoning ordinances and subdivision regulations (where they exist). Market forces will be less constrained than under a strategy where reliance on soil absorption systems will cause densities to be in compliance with N.C. Division of Health Services and local health departments regulations regarding the size of drain fields and repair areas. The provision of sewered systems could lead to a significant increase in multi-family dwelling unit and lodging facilities construction.

Under the 201 Strategy, depth to seasonal high groundwater is no longer a development constraint. Permits will still be required by CAMA for development in Areas of Environmental Concern, but developers could site construction immediately adjacent to marshes and other wetlands.

b. Financial Impacts

Costs were developed in each 201 Plan for the selected wastewater management plan. For comparison purposes, it is necessary in this EIS to express the 201 costs in a manner comparable to each other and to the EIS Strategy alternatives. Therefore, all 201 costs except for Hatteras Island* were adjusted to the June 1981, Birmingham, ENR Index 2615.33. The Birmingham value was used rather than the National Average because it is more representative of costs in the southeastern U. S.

Some of the 201 Plans included areas on the mainland. Only costs for wastewater management systems on the barrier islands are tabulated in this EIS, however. All of the 201 Plans presented costs for complete wastewater systems except in the Dare Beaches 201 Plan, where costs were not developed for a collection system. Costs for a collection system in this area were estimated by the EIS using data from the 201 and the following assumptions:

- A grinder pump low pressure system was chosen because it had been found to be appropriate for similar areas in some other 201 studies.
- Sixteen feet of collector per person, including laterals (EPA 1977), was used.

Table II.19 contains the costs (in 1981 dollars) of the five 201 Plans. Costs are shown with and without federal and state assistance. Local costs include capital costs not eligible for federal or state funding and operation and maintenance (O&M) costs. The capital costs for all components of a wastewater management system, except for the collection system, are eligible for 75 percent federal funding and 12.5 percent state funding**. Collection lines are presumed only eligible for a maximum of 25 percent state funding. The capital costs for service laterals (the lines which connect users to the collection system), however, would be strictly local costs.

Table II.20 contains a delineation of user charges for the five 201 Plans. The column, Dwellings, contains the typical household monthly charge for each 201 Plan. This figure was also used in Figure II.21 as part of the affordability analysis of the EIS Strategy. As mentioned previously, only

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* The 201 consultants recommended the No Action Alternative; therefore, this 201 Plan will be dropped from further discussion in the EIS.

**Systems receiving federal funding after October 1, 1984 will be limited to 55 percent of eligible costs for conventional systems and 75 percent for innovative/alternative systems. Levels of state assistance are not yet known.

Table II.19. Wastewater System Costs (1981) of 201 Facility Plans.

201 Plan	Total Costs*					Local Costs Based on Federal and State Assistance*			
	Total Capital[1] Costs	Annual O&M Costs	Total Present[2] Worth	Total Annual Costs	Total Avg. Household Cost/Mo.	Local Capital Costs	Local Annual Capital[3] Costs	Total Local Annual Costs	Local Present Worth[4]
Southwestern Brunswick County	12,679	254	15,090	1,593	69.68	6,822	721	975	9,229
Southeastern Brunswick County	36,599	518	41,510	4,381	94.48	12,636	1,336	1,854	17,544
Topsail/Surf City	17,050	379	20,640	2,178	46.86	7,100	750	1,129	10,691
Carteret County	12,007	277	14,630	1,544	37.20	5,654	598	875	8,279
Dare Beaches	34,909	810	42,580	4,494	30.47	16,104	1,702	2,512	23,779

All costs at ENR Index 2615.33
*Costs shown are in thousands of dollars except Total Average Household Cost/Month.

[1] Total Capital Costs + (Annual O&M Costs x 9.475); Based on 7 3/8 percent discount rate, 20 years.
[2] Total Present Worth ÷ 9.475; Based on 7 3/8 percent discount rate, 20 years.
[3] Local capital costs X .1058; Based on 8 1/2 percent interest on bonds for 20 years.
[4] Local capital costs + [Annual O&M costs X 9.475]; Based on 7 3/8 percent discount rate, 20 years.

Source: Consoer, Townsend and Associates. 1978. Southeastern Brunswick County Facilities Plan.

Wm. F. Freeman Associates. Henry Von Oesen and Associates. 1979. Carteret County Complex 201 Facility Plan.

Henry Von Oesen and Associates. 1980. Topsail/Surf City 201 Facility Plan.

Henry Von Oesen and Associates. 1977. Dare County Complex 201 Facilities Plan.

Pierson and Whitman Inc. 1979. Southwest Brunswick County 201 Facilities Plan.
Gannett Fleming Corddry & Carpenter, Inc. 1981.

Table II.20. Wastewater System Monthly User Charges of 201 Facility Plans Assuming Federal Assistance.

201 Plan	Dwellings[1] ($/Dwelling)	Motels[2] ($/Room)	Restaurants[3] ($/Seat)	Stores[4] ($/Facility)	Laundries[5] ($/Machine)	Campsites[6] ($/Site)
Southwestern Brunswick County	36.35	18.17	5.83	36.12	72.23	21.67
Southeastern Brunswick County	34.33	17.05	5.46	34.11	67.98	20.46
Topsail-Surf City	18.39	10.41	3.38	20.69	41.52	12.44
Carteret County	21.10	8.96	2.88	17.91	35.82	10.78
Dare Beaches	17.10	7.18	2.39	14.54	28.90	8.72

[1] Assume 4.2 persons per dwelling; per capita flows used were those defined by 201 Plan.
[2] 125 gal/room/day
[3] 40 gal/seat/day
[4] 250 gal/fixture/day
[5] 500 gal/machine/day
[6] 150 gal/campsite/day

Note: These costs presume EPA and state funding. Costs without funding can be estimated by multiplying these figures by the ratio of total to local present worth costs from Table II.17.

Source: Consoer, Townsend and Associates. 1978. Southeastern Brunswick County Facilities Plan.

Wm. F. Freeman Associates. Henry Von Oesen and Associates. 1979. Carteret County Complex 201 Facility Plan.

Henry Von Oesen and Associates. 1980. Topsail/Surf City 201 Facility Plan.

Henry Von Oesen and Associates. 1977. Dare County Complex 201 Facilities Plan.

Pierson and Whitman Inc. 1979. Southwest Brunswick County 201 Facilities Plan.

Gannett Fleming Corddry & Carpenter, Inc. 1981.

the user charges for the 201 Plans in Topsail/Surf City, Carteret County and Dare Beaches are affordable, assuming 75 percent EPA funding and 12.5 percent state assistance toward eligible costs.

c. Implementability

Implementation of the 201 Strategy requires that the state certifies the 201 Plan and prepares a Finding of No Significant Impact. Final decisions must be made about financial and institutional arrangements. In many instances cost data were not fully developed and thus local governments are not fully cognizant of the financial impacts of capital expenditures and operation and maintenance expenses. Financial resources are modest in most barrier island communities, and thus the issue of affordability could have a significant impact on implementation of the 201 Plans. The following tasks could be very time consuming, particularly where multiple jurisdictions are involved.

Financial arrangements include:
- Cost of collection systems (in some cases)
- Development of user charges
- Structuring of capital costs
- Budgeting for administrative costs of a new management agency
- Conducting public hearings to present these cost data to system users

Institutional arrangements require:
- Selection of a management agency (in some cases)
- Establishment of a management agency
- Review and approval of bond issue referenda by the North Carolina Local Government Commission
- Preparation and adoption of joint management agreements (in some cases)
- Preparation and adoption of local ordinances as necessary to implement the above financial and institutional arrangements

The selection and establishment of a management agency could be a time consuming project, particularly when multiple communities are involved. However, it is unlikely that 201 monies would be made available in the absence of a clear understanding by all parties of who would administer the grant and wastewater management system. The management skills associated with operating a regional system require a more complex and sophisticated administrative system than now exists in most barrier island communities.

Political resistance could be met from citizens about hook-on requirements, user charges, the potential for high density development provided by the availability of sewers and other growth management issues. Should these issues arise, they could present formidable difficulties in implementing the 201 Strategy.

Another barrier to implementation could be the place of each 201 Plan on the state's priority list for funding. State approval of a 201 Plan does not guarantee its funding. Recent major reductions in 201 Construction Grant funds may delay the implementation of a given 201 to the extent that the community must abandon the 201 Strategy and seek alternative solutions.

d. Timeliness

This section evaluates the amount of time required to implement the 201 Strategy. The activities contained in the overall timeframe span the period from the date when the EIS is published until systems design and construction begins. Table II.21 lists the activities contained in the strategy's timeframe.

Table II.21. 201 Strategy: Program Activities.

1. Final Environmental Impact Statement is published.
2. Undertake or complete ocean outfall study where applicable and fully identify financial and institutional arrangements.
3. State prepares certification and Finding of No Significant Impact (FNSI).
4. EPA reviews 201 Plan and FNSI and approves FNSI.
5. Interlocal agreements are signed and management agency is put in place.
6. 30-day comment period on FNSI is provided.
7. If no negative comments are received, Step 2 and Step 3 monies are granted subject to available funding and the applicant's position on the state's priority list.
8. Application to state agencies for permits.
9. Local share (12.5 or 7.5 percent) capital funds are raised after approval by the North Carolina Local Government Commission.
10. Design and construction begin.

Source: EPA, Region IV. NEPA Compliance Section. 1981.

The following discussion focuses on the range of time which might be required by key activities comprising each strategy.

Activity 2. Completing or undertaking ocean outfall studies will be required in two of the 201 planning areas. Water quality studies might be required in some of the areas by the state before certification. In all cases, financial and institutional arrangements must be fully identified. Although these activities could be conducted concurrently, they represent several man months of effort.

Activity 5. The amount of time required to sign interlocal agreements and put a management agency in place will largely be a function of how many political jurisdictions are involved. Preliminary work should start as soon as possible after the Final Environmental Impact Statement is published since it could be a very lengthy process.

Activity 7. The current position of each 201 Plan on the state priority list is known, but how soon funding will be made available for each 201 Plan cannot be determined at this time.

e. Reliability

The 201 Strategy, as currently proposed, calls for construction of large, centrally-located wastewater treatment plants. These plants would be required to achieve, at a minimum, secondary effluent standards which mandate a relatively complex treatment train.

The mechanical reliability of these plants is considered to be lower than the systems proposed under the EIS Strategy, although the quality of operation and maintenance provided will be a major determining factor. The process trains would be more easily impacted by stress factors; however, with the plants located on the mainland, the opportunity for storm damage would be reduced. Given equal storm force, a centralized system with above-ground structures would be subject to greater damage than would decentralized soil absorption systems. Operator reliability would be considered high for centralized systems. A negative factor with these systems would have to be the potential for greater and more widespread environmental damage if the system should fail.

C. No Federal Action Strategy

The No Federal Action Strategy is a baseline for evaluating the environmental impacts of the other two strategies. It projects future conditions on the North Carolina barrier islands in the absence of federal investment in wastewater facilities.

Analysis of the No Federal Action Strategy shows continued growth on the barrier islands if publicly-owned and funded sewage treatment facilities are not constructed. In concept, this alternative does not restrict state, local, or private investment in wastewater management. However, without the support of federal funds, the amount and the nature of additional treatment capacity in the study area could be different in the future than under the alternative strategies discussed previously.

Growth would take place in response to previously committed investments and continuing pressures for new residential construction that would be accommodated in large part either by hook-up to existing systems, individual on-site treatment systems, or by privately-owned package plants and other community systems. Thus, no federal action does not imply lack of growth. The major differences between the No Federal Action alternative and the other alternative strategies would be the density of development, the viability of some of the private real estate developments in the area, and the total and individual costs of wastewater management. Impacts on the natural environment could also be expected to differ under the funding and no-federal-funding alternatives.

Based upon current technical, institutional, and financial mechanisms, projections can be made about how the barrier island communities will develop if they must finance wastewater treatment facilities without federal assistance. Impacts expected to result from the implementation of the No Federal Action Strategy will also be discussed.

1. Description of the Strategy

In the event federal funds are not available, future development will rely largely on soil absorption systems, with individual on-site or community systems. Strict state regulations protect SA shellfishing waters; hence there is a low probability that new surface discharges will be allowed. Surface discharges may be approved, however, if areas currently designated SC can be shown to have sufficient assimilative capacity to handle additional effluent and adjoining SA waters would not be affected by the new discharge.

Land availability on barrier islands is a major factor constraining the acquisition of large spray disposal sites. Generally, local property owners are unwilling to pay the total cost of central/regional facilities requiring mainland disposal sites or ocean outfalls. In addition, communities north of Cape Lookout would almost certainly use soil absorption systems because of the long distance to the mainland. Southern barrier island communities may still find mainland disposal a viable alternative, depending on land and effluent transmission costs. The ocean outfall option still exists, but the cost of individual community financing of this disposal alternative appears to be prohibitive.

Regional treatment systems are improbable without federal funding. Adjacent communities would need to view their wastewater treatment needs as similar in order to consider the coordinated arrangements necessary for a regional system. In addition, the capital costs of a regional system must be supplied by the local population, many of whom may view the expense as unnecessary since their existing systems are adequate.

However, a regional system using an ocean outfall may be considered in the Dare Beaches area. Capital costs for collection, transmission, treatment, ocean outfall, and sludge removal would be high. Operation and maintenance costs represent a new municipal expense not currently associated with soil absorption systems. In all other areas, the low density of existing development and the high cost of regional systems preclude their use in the absence of federal funds.

If central and regional systems cannot be used, then future development must rely on on-site and community systems. On-site systems would be used for individual homes and businesses and would be selected to match the proper soil suitability. A broad array of soil absorption systems could be used, ranging from pressure dosed mounds to conventional septic tank/drain field configurations.

On lots which are incapable of using soil absorption systems, the increased use of alternative/innovative treatment systems, such as composting toilets, may be used. An alternative to individual innovative systems would be to join with other owners with the same problem and install a community system servicing several parcels.

Some existing development will require new technical solutions because wastewater treatment systems will occasionally fail due to improper installation, overuse or neglect. As renovation of existing systems proceeds, the failure rate should decline. Systems installed since 1977 are less likely to fail because state guidelines have been followed in siting and installing these newer systems.

Management of on-site wastewater treatment systems will remain the responsibility of the property owner, including construction, operation, and maintenance. Local and state agencies will remain involved in the initial approval of on-site systems and the identification of problems and remedial measures. Subsurface systems will be regulated by the Division of Health Services of the Department of Human Resources. No new local regulations are expected unless a centralized system is built necessitating sewer use ordinances or user charge regulations.

Areas of Environmental Concern will remain under the protection of the Coastal Management Program, administered by the state and local governments. Lands outside the AEC's must conform to local land use plans prepared under the Coastal Area Management Act. These development guides are not affected by EPA funding and would apply in the absence of federal monies.

Planning for integrated water quality management may be effectively eliminated without federal assistance. Currently, federal funds allow and encourage evaluation and planning among neighboring units of government to address water pollution problems that may be solved collectively. Loss of federal funding will encourage local communities to assess only their own problems, thus leading to local solutions which may overlook economies of scale available under multi-jurisdictional solutions.

2. Impacts of the No Federal Action Strategy

This section describes some of the impacts that can be expected if the No Federal Action Strategy is implemented. These impacts will be compared with those of the other strategies in Chapter IV. Impacts on development potential, financial impacts, implementability, timeliness and reliability are discussed below.

a. Development Potential

Impacts on development potential under the No Federal Action Strategy could be similar to the EIS Strategy. Densities would likely be lower than under the 201 Strategy. Development is more likely to occur on soils suitable for on-site systems.

b. Financial Impacts

The costs of small community systems and individual on-site systems were previously presented in Tables II.9 and II.10 respectively. Under the No Federal Action Strategy, user charges would be those shown as the Total Monthly Cost, reflecting the absence of federal assistance with capital costs.

As shown in Figure II.21, many of the individual on-site technologies fall within the affordable range, although costs of mound systems may exceed the guidelines for average households. On the other hand, mound systems will only be required in situations where conventional on-site systems are not appropriate.

Some small community systems will be affordable in the absence of federal funding but several will not be. The range of user charges is shown in Figure II.21 and reflects specific technologies listed in Table II.9.

c. Implementability

Implementation of central or regional wastewater management systems will be difficult, if not impossible, under the No Federal Action Strategy. Few municipalities will be able to afford the capital and operation and maintenance costs of these systems in the absence of federal funding. Despite some assistance from the state, perhaps as much as 25 percent matching funds, local governments will be hard pressed to meet project costs.

Bond issue referenda to raise funds for capital costs must be reviewed by the North Carolina Local Government Commission. Even with the Commission's approval, voters may reject a referendum. Their objection may center on either the size of the bond issue or the user fees that the project would ultimately require. Many property owners may be reluctant to abandon functioning on-site systems and bear the costs of tapping on to a central or regional system.

Assuming then that the No Federal Action Strategy will result in a continuation of present practices, no significant barriers to implementation of the strategy are anticipated. Individual property owners will in large part rely on on-site systems, and developers of high density properties will provide small community systems. Costs and management activities will continue to be the responsibility of individual homeowners and developers. Difficulties could arise, however, in situations where individual homeowners must organize to implement small community system solutions in areas of malfunctioning septic tanks.

Local governments may choose to set up management districts to operate and maintain on-site and small community systems in order to centralize the management function, decrease the risk of water quality degradation and supervise the rehabilitation of failing on-site systems when small community system solutions are indicated. An innovative practice such as a management district might meet initial resistance from the public unless an effective public education program were carried out.

d. Timeliness

Timeliness is not a consideration that applies to the No Federal Action Strategy. Once the EPA Regional Administrator makes the No Federal Action decision, each community proceeds with its wastewater management plans in accordance with its needs and own resources.

e. Reliability

On-site systems and many small community systems are expected to be the predominant methods for wastewater treatment under the No Federal Action Strategy. Mechanical reliability of these systems, when new, will probably be reasonably high. However, operator reliability will be quite low, and the potential for mechanical failure will increase substantially as the systems age. Process reliability also will be good in new systems, but will degrade with time if maintenance responsibilities are not carried out consistently. Due to a lack of centralized management, monitoring programs may not be established, and adverse water quality impacts may not be detected and corrected. The potential for storm damage and slow recovery afterwards will be highest under this strategy.

CHAPTER III. AFFECTED ENVIRONMENT

A. Natural Environment

Barrier islands are probably one of the better examples of an environment manipulated by interacting physical and biological processes. Important physical elements include water (waves, currents, tides, floods and salinities), wind, climate (weather, storms), and soils. Biological elements include the various plants and animals occurring within the communities of the marine, estuarine, freshwater and terrestrial habitats.

In discussions of the barrier island ecosystem, certain concepts should be emphasized, particularly the pervasiveness of change in these systems. Island configurations, locations and ecological communities are continually subject to alterations by changing environmental conditions. Although there is a resulting tendency to view island features as unstable, in a broader context the islands exhibit a large degree of dynamic stability. For instance, although maps document that the configuration of Cape Lookout has changed dramatically within the last century, the total land area has remained nearly constant (Godfrey & Godfrey 1976).

Another important concept pertaining to the barrier islands is the interrelatedness of various environmental components and processes. Ecological communities often intermix in the transition zones between different types.

The climate on the barrier islands is moderated by the water surrounding the islands and is subject to seasonal variations. Summer highs range from 40° to 45° C (95° to 104° F) and winter lows range from -17° to -13°C (5° to 12° F). Annual precipitation ranges from 113.5 cm (44.7 in.) at Norfolk to 141.2 cm (55.6 in.) at Cape Hatteras. The most dramatic weather conditions in North Carolina result from tropical storms, hurricanes and northeasters. Since the 1960's no large hurricanes have affected this area. This trend cannot be expected to continue. Since 1960 there have been some large northeastern storms, the most severe being the "Ash Wednesday Northeaster" of March 1962.

The following discussion of the natural environment divides resources into the following major groupings: ecological inventory, surface water resources, groundwater resources, geological resources and sensitive areas. A more detailed treatment of each subject is found in the Technical Reference Document, Environmental Inventory Report.

1. Ecological Inventory

This section of the EIS describes the habitats found within the aquatic and terrestrial ecosystems of barrier islands. Major categories include freshwater, estuarine, marine and terrestrial ecosystems. Because of complex relationships between the ecosystems, wastewater management decisions that impact one ecosystem may cause widespread and unanticipated effects on other ecosystems.

a. Freshwater Ecosystems

The freshwaters of the barrier islands are generally restricted to small to medium sized ponds, marshes and swamps. These standing water systems are supplied by the groundwater table and from rainwater. No running water streams are found on the barrier islands except during times of heavy rains when various freshwater ponds and marshes may be connected. Any contamination of groundwater resources by point or nonpoint sources could have adverse impacts on freshwater ecosystems.

(1) Pond Habitat

The intrusion of salt water will affect freshwater communities. The most direct negative effects on these systems come from nonpoint runoff from adjacent developed areas and feral grazing animal populations. In areas where water quality is high, fauna can be expected to include numerous insect groups, oligochaetes, reptiles and amphibians. The dominant fish species are mosquito fish, minnows, killifishes and sunfishes, (U.S. Dept. of Interior 1978, 1980). The ponds are basically a plankton based food chain, and the fringes of these ponds are dominated by emergent vegetation.

(2) Swamp Habitat

Swamps are wetland communities dominated by woody vegetation. Swamps usually occur in low swales that are regularly flooded by freshwater. On the North Carolina barrier islands, swamps are very limited in extent, being most common within maritime forest stands located at Carolina Beach, Bogue Banks, Cape Hatteras at Buxton Woods and Bodie Island near Nags Head (N.C. Natural Heritage Program, undated).

Bald cypress and swamp gum are typically the dominant plant species at very wet sites, but red maple, sweetgum willows and buttonbush may also be important. Herbaceous plant cover is usually limited, but may include species typical of freshwater marshes.

Due to their high productivity, diversity, dense cover, and abundance of fresh water, swamps are valuable wildlife habitats. A greater variety of animals utilize swamps than any of the other interior barrier island communities except freshwater marshes. Amphibian, reptile and mammal species use swamps extensively including the threatened American alligator. Particularly noteworthy are the various species of wading birds (herons, egrets, rails and ibis) which often nest in swamps, sometimes forming large colonies or rookeries.

(3) Marsh Habitat

Freshwater marshes are wetland communities dominated by herbaceous vegetation. Some of these areas may contain brackish water. Freshwater marshes are found throughout the barrier islands. Although usually small in size, extensive freshwater marshes occur at Cape Hatteras, Pea Island and Bodie Island near Nags Head (Burk 1962).

Although communities at different sites may vary considerably in species composition, plants which are usually dominant or abundant in freshwater marshes include saw grass, cattails, spikerushes, needlerushes, bulrushes, sedges and bladder rushes. Woody shrubs, such as buttonbush and willows, may also be important, especially around the edges of marshes.

Because of the high productivity and diversity of vegetation and the abundance of fresh water, marshes are valuable wildlife habitats. Particularly noteworthy are the large variety of wading birds and waterfowl which feed and nest in freshwater marshes. Freshwater marshes are also the primary habitat of the American alligator.

Freshwater wetlands are also potential disposal sites for treated effluent. EPA Region IV is presently preparing a generic Environmental Impact Statement which examines the capability of wetland systems to serve in this capacity. Barrier island wetlands should be protected so as to preserve their capacity for this use if appropriate.

b. Estuarine Ecosystems

Estuaries are complex ecosystems and are extremely difficult to characterize. These areas are enriched naturally from the transport of organics from adjacent terrestrial areas, natural nutrient recycling in component estuarine subsystems, and transport of nutrient material from the freshwater rivers. These ecosystems are extremely important to marine shellfish and finfish because they provide not only an abundance of food but also a breeding and nursery ground for many of the commercially important species.

Wastewater management systems which are not properly installed, operated and maintained have the potential for causing degradation of estuarine water resources and the closing of shellfish beds.

For the purposes of this EIS, the estuarine region behind the barrier islands can be divided into six separate subhabitats: sand and mud sediment, saltmarsh, seagrass beds, oyster reefs, open-water plankton systems, and oligohaline systems.

(1) Sand and Mud Sediments Habitat

The open sand and mud sediment areas are the dominant benthic habitats in the estuarine zone. These habitats represent both intertidal and subtidal sediment areas where there is no submerged or rooted vegetation. In general, the open sediment habitat is dominated by numerous burrowing infaunal and surface epifaunal species.

Figure III.1 shows the relationships of the component estuarine subsystems and the dominant species that inhabit this area. The community is dependent on the transportation of organic material from adjacent areas of the estuary. However, there is primary production from the many species of benthic diatoms and dinoflagellates. The dominant invertebrate species in the sediment areas are mollusks, crabs and shrimp. In general, these sediment areas have numerous species and are in a healthy condition along the barrier island chain (Peterson and Peterson 1979).

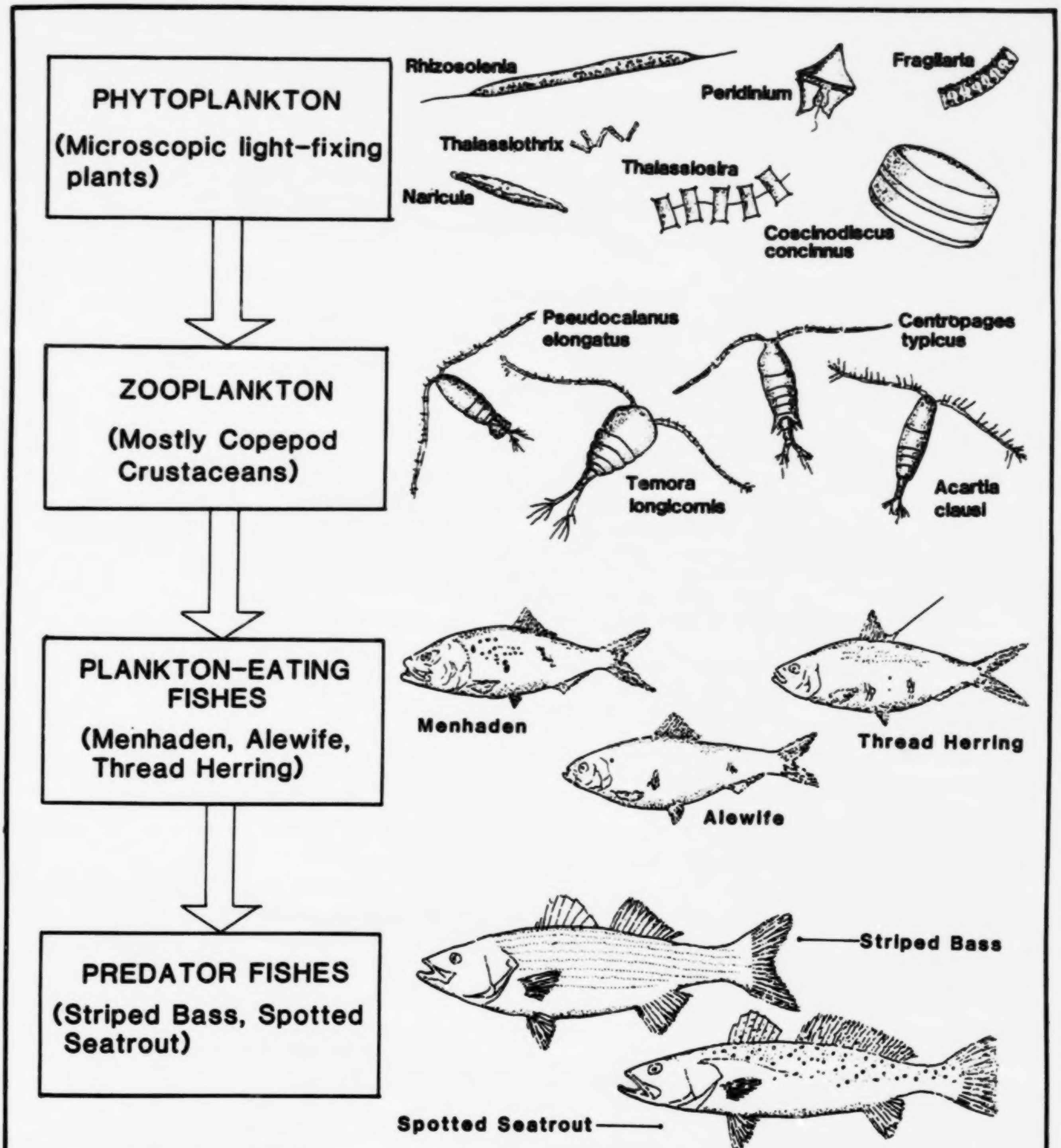

PHYTOPLANKTON
(Microscopic light-fixing plants)
Rhizosolenia
Peridinium
Fragilaria
Thalassiothrix
Thalassiosira
Naricula
Coscinodiscus concinnus
ZOOPLANKTON
(Mostly Copepod Crustaceans)
Pseudocalanus elongatus
Centropages typicus
Temora longicornis
Acartia clausi
PLANKTON-EATING FISHES
(Menhaden, Alewife, Thread Herring)
Menhaden
Thread Herring
Alewife
PREDATOR FISHES
(Striped Bass, Spotted Seatrout)
Striped Bass
Spotted Seatrout

Figure III.1 Basic Food Chain of North Carolina Estuarine Plankton Systems (from Odum et al. 1974).

(2) Saltmarsh Habitat

Saltmarshes are wetland communities dominated by herbaceous plants which are periodically inundated by tidal fluctuations of saltwater. Saltmarshes are abundant in the study area, being most extensive on low wave-energy shores on the inland sides of barrier islands. Due to their high productivity, these are valuable ecological communities, and provide a basis for both terrestrial and marine food webs. Because of their drainage characteristics, saltmarshes may be vulnerable to water pollution and dredge and fill activities. Developments occurring in saltmarshes generally require permits from the Army Corps of Engineers and the Coastal Resources Commission.

Low saltmarshes are almost entirely dominated by smooth cordgrass and are regularly flooded by tides. High saltmarshes which are inundated less frequently, are largely dominated by black needlerush or saltmeadow cordgrass. Other plant species which are frequently abundant in the saltmarshes include the glassworts, saltgrass and sea ox-eye. In the transition areas between saltmarshes and upland communities, a shrub zone of wax myrtle, marsh elder and silverling is often present.

Saltmarshes support immense populations of invertebrates, which ultimately rely on the plants of this community for food sources as well as nursery grounds. These invertebrates, in turn, provide food for an abundance of marine, estuarine and terrestrial wildlife.

(3) Seagrass Bed Habitat

Typically, two seagrass species occur in the estuarine region behind the barrier islands: eel grass (*Zostera marina*) and shoal grass (*Halodule beaudettei*) (Phillips 1974, Roberts 1974). These seagrasses are especially important as a nursery ground and feeding area for many species of commercial finfish (Adams 1976, Kikuchi 1966, Robertson 1977). These beds are also important in the maintenance of the entire estuary, in that they provide protection from predators for many juvenile finfish and shellfish, a direct and indirect food source for estuarine species, oxygen to adjacent estuarine waters, substrate and habitat for many species of flora and fauna, and act as a sediment trap to stabilize bottom sediments (Phillips 1974).

Numerous bait fish (anchovies, killifishes and silversides) and larger juvenile finfish (drums, porgies, flounders, grunts and mullets) forage through these beds for food or use them for protection from predators. Some of the commercially important shellfish that use the seagrass beds in North Carolina include the bay scallop, soft shell clam, hard clam, and the pink, white and brown shrimps (U.S. Dept. Interior 1978, 1980).

(4) Oyster Reef Habitat

These reefs are based upon the successive generations of the common oyster (*Crassostrea virginica*). Oyster reefs serve as a hard substrate for an abundance of estuarine life (Odum et al. 1974) and are often found in close proximity to saltmarsh systems or extending into the tidal creeks. They may also be found interspersed with the submerged seagrass community since stable sediment is needed in order for oysters to successfully settle and form a reef community. This habitat is illustrated in Figure III.2.

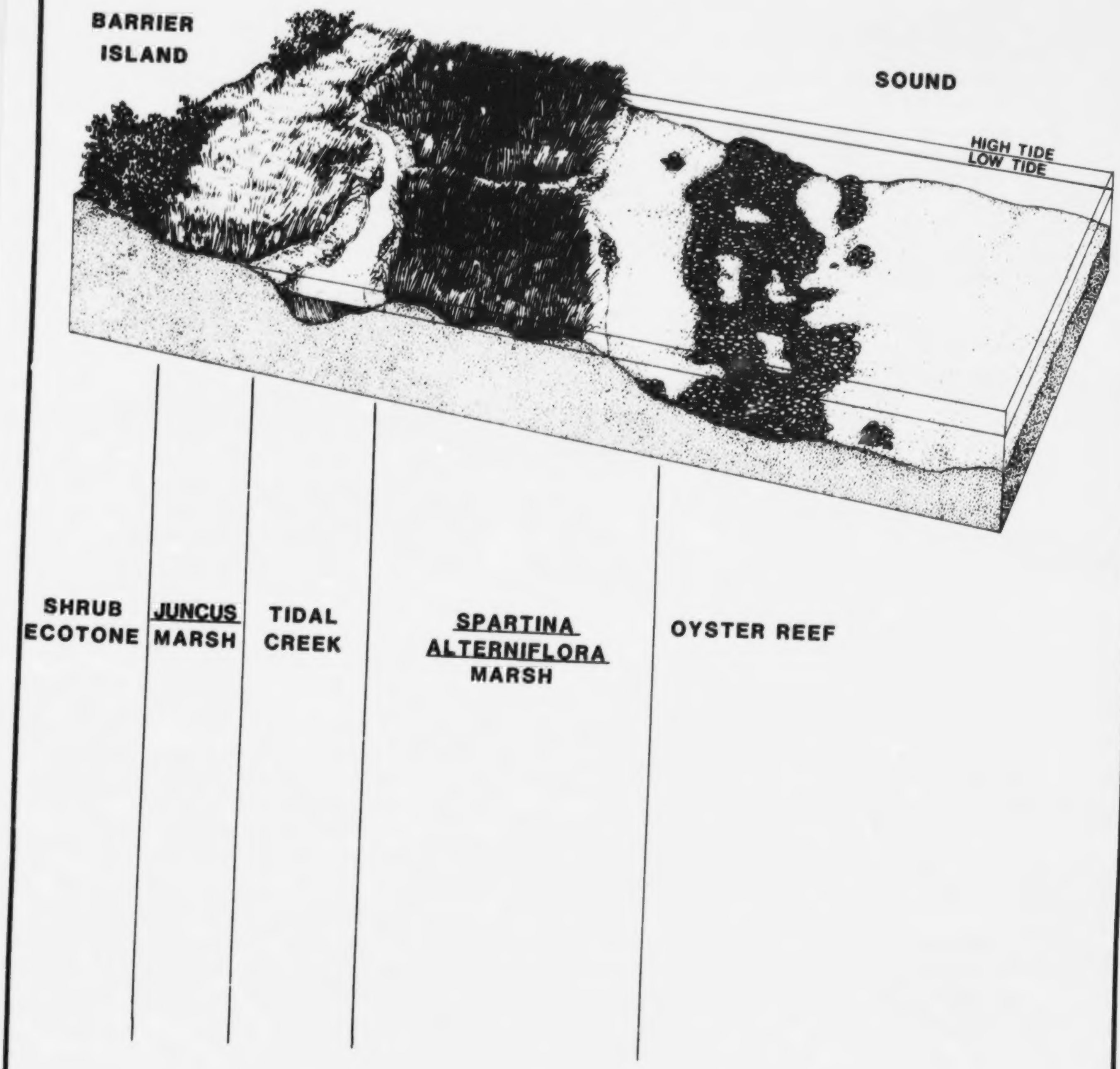

BARRIER ISLAND
SOUND
HIGH TIDE
LOW TIDE
SHRUB ECOTONE
JUNCUS MARSH
TIDAL CREEK
SPARTINA ALTERNIFLORA MARSH
OYSTER REEF

Figure III.2 Typical View of North Carolina Saltmarsh and Oyster Reef Association.

Oysters are filter feeders and thus dependent on the transport of food materials from other parts of the estuary (seagrass beds, saltmarsh and the water column) for their survival (Odum et al. 1974). Because of the hard substrate, numerous sessile organisms are able to form an important part of these communities. Beside the oyster, other invertebrates such as the stone and blue crab have commercial value for this area.

The dominant fishes from oyster reefs include gobies, blennies and pinfish. Because of these numerous bait fishes, many of the larger fish species (bluefish, croaker, spot, seatrout, mullet and striped bass) will also congregate around these reefs as they forage for food. Many of these species are of commercial importance.

Perhaps the greatest hazard to oyster production is dredge and fill operations which cover oyster reefs with silt. Currently, oyster reefs are still widely distributed in the state, but degradation in these oyster reef zones has occurred due to lower salinities and pollution. The closing of oyster beds to harvesting due to high coliform counts has been a major issue of this EIS.

(5) Open Water Plankton Habitat

The open water plankton zone includes all the water column areas above all the previously mentioned benthic zones. The water column zone is a phytoplankton-zooplankton based system which can be termed a medium salinity ecosystem (Odum et al. 1974). The open water zone is important to the maintenance of the entire estuary because, together with the tides and currents, it serves as the transport vehicle for the removal of waste products and provides food materials to other parts of the estuary (saltmarshes, seagrass beds, benthic sediments, etc.) (Bellis 1974).

(6) Oligohaline Habitat

Oligohaline (low salinity) systems have a range of between 0.0 to 5.0 ppt. Oligohaline systems can be found in all the river mouths on the mainland side but mainly in Currituck Sound down to Roanoke Island behind the barrier islands. This is a harsh environment, and usually the number of species is reduced from that of the higher salinity parts of the estuary. Organic detritus and phytoplankton form the basis of the food chain that ends in the large predator fish (striped bass, spot, flounder, etc.) (Odum et al. 1974).

c. Marine Ecosystems

In general, offshore marine systems are more diverse, in terms of invertebrate and fish species, than the estuarine systems. However, while species diversity is high, relative abundance is lower than that of estuarine systems. The marine systems extend offshore to the Gulf stream and contain elements of tropical and temperate faunal organisms. The offshore marine systems consist of the high energy beaches and associated intertidal and subtidal sandy benthos as well as nearshore plankton system and hard bottom communities.

(1) High Energy Beach Habitat

The high energy beach and open sediment areas are the dominant features of the nearshore marine region and represent both intertidal and subtidal areas. These areas are characterized by highly unstable sands; currents and tides cause the continuous movement of sediment along the coast. Because these benthic habitats are constantly shifting, most of the organisms are burrowing types.

(2) Open Water Habitat

The open water column zone includes all the open waters over the sedimentary areas from the wash zone of the barrier island beaches to approximately the 50 meter depth contour line. The food chain is based upon small plant species and small crustacean and larval species which are the food for numerous fish species. The organic material produced in the plankton community settles to the bottom areas and provides nutrients to the benthic communities. The nearshore coastal zooplankton is usually dominated by the copepods *Acartia tonsa* and *A. clausi* (Odum et al. 1974, Sutcliffe 1950). Small fish such as anchovies, round scad, butterfish and menhaden feed on the plankton and are eaten in turn by such commercially important species as bluefish, spanish and king mackeral and amberjack.

(3) Reef Habitat

In the area south of Cape Hatteras, rock outcroppings are found which support large numbers of sessile organisms and fishes. These areas are known to local fishermen as "live bottoms" or "snapper banks". Reef communities can be found in two general categories: 1) natural reefs from rock outcroppings and hard bottoms and 2) artificial reefs from sunken ships and created reefs.

In the nearshore marine zone, natural reefs are small and not widely distributed. These areas are usually dominated by sessile organisms and small amounts of hard corals. Fish are attracted to these areas for food and shelter. Another "live bottom" area off the coast of Cape Lookout also exists in the nearshore marine system supporting a large commercial concentration of calico scallops (U.S. Dept. of Interior 1978, 1980). The artificial reefs consist of the numerous ship wrecks and near-shore reefs created by man to attract fish. Many of the offshore reef fishes can then be caught within reach of small sport fishing boats.

d. Terrestrial Ecosystems

(1) Dunefield Habitat

Dunefields include the system of sand dunes generally running parallel to and including the upper beaches. Being closest to the ocean, dunefields are regularly exposed to harsh environmental conditions, which are further intensified during storms. Figure III.3 illustrates dunefield dynamics.

Dunefields are extremely important to the barrier island ecosystem by forming a buffer zone between the ocean and interior island communities, which are less resistant to environmental extremes. Accordingly, the

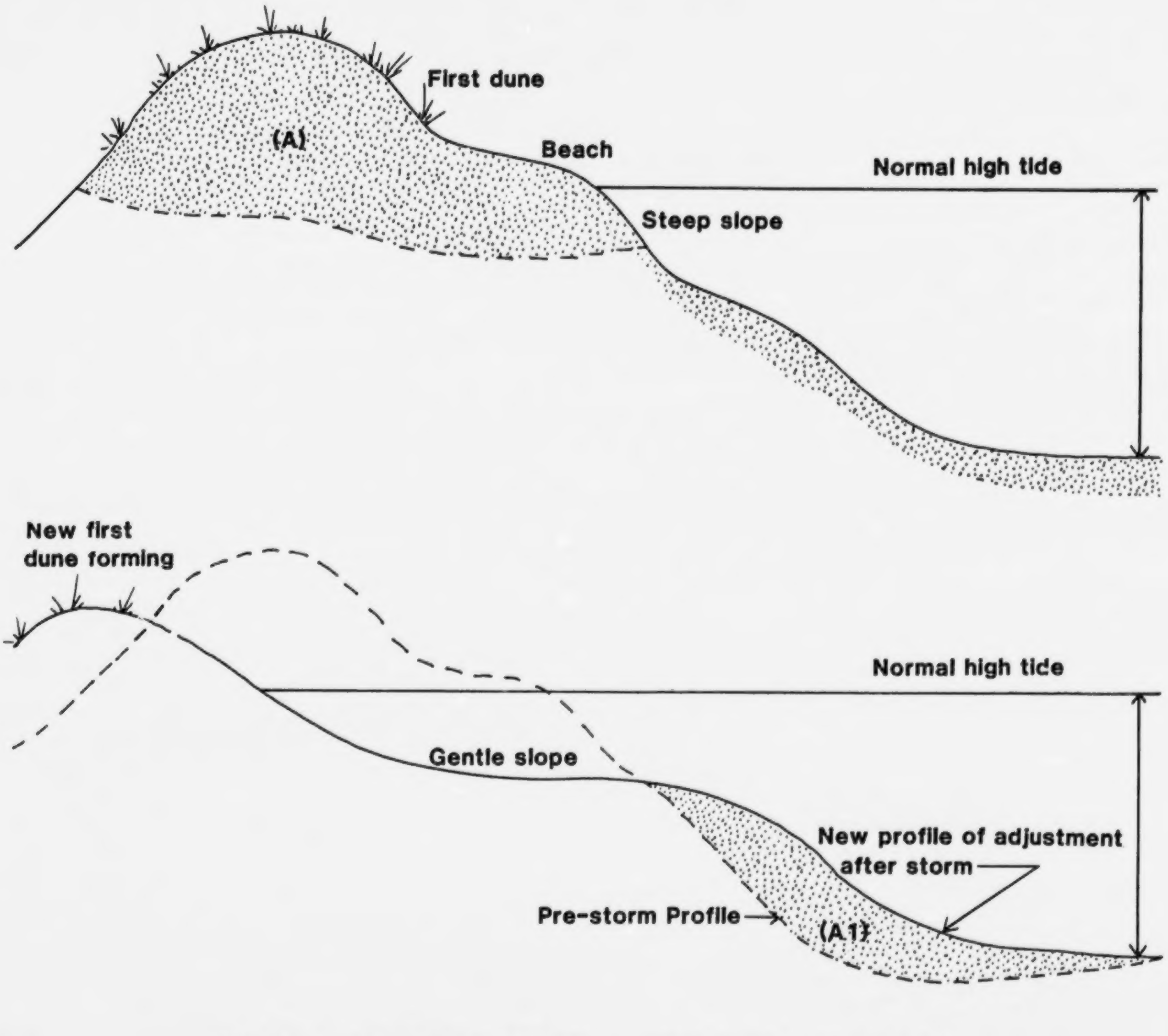

First dune
(A)
Beach
Normal high tide
Steep slope
New first
dune forming
Normal high tide
Gentle slope
New profile of adjustment
after storm
Pre-storm Profile
(A1)
(Shaded area A1 is approximately equal to shaded area A.)

Figure III.3 Beach Flattening in Response to a Storm
Source: Adapted from Pilkey, et. al., 1978.

137<

destruction or alteration of dunefields can result in increased beach erosion, greater susceptibility to overwashes and flooding, the drifting of sand dunes, and increased potential for damages to wastewater management systems during storms.

The vegetational cover of this community is adapted to the intense salt spray, high winds, and unstable, infertile and dry sand soils. The most conspicuous plants are sea oats. Other abundant species include saltmeadow cordgrass and dune bluestem. Sea rocket and croton are notable colonizers of the upper beaches (Parnell & Adams 1970, Au 1974). Different species dominances are present on the stabilized barrier islands from Ocracoke northward. The dunefields on these islands have been intensively planted with beach grass, which replaces sea oats as the dominant species; panic grasses and purple sandgrass are also commonly abundant (Levy 1970, Dolan et al. 1973).

Dunefields do not contain a large variety or abundance of wildlife, mainly due to the limited food sources (Parnell & Adams 1970). A protected species, the loggerhead sea turtle, uses the upper beaches of this habitat for nesting throughout the study area south of Pea Island.

(2) Grass Flat Habitat

Grass flats frequently occur on low, level grounds behind dunefield systems and on re-vegetated overwash areas, especially on narrow and sparsely vegetated barrier islands. The water table is frequently high in these areas, and drainage may be impeded during rainy periods or after floods. Such areas are not suitable for development with on-site soil absorption systems.

Grass flats contain many of the same plant species found in the dunefield community, but species dominances are different and vegetational cover is usually much denser and more diverse. Sea oats, saltmeadow cordgrass, seaside goldenrod, panic grasses, purple sand grass, sand spur, broomsedge, marsh elder, wax myrtle, silverling, and (above Cape Hatteras) bayberry and beach heather are dominant species. Grass flats are of limited value as wildlife habitat because of the relative paucity of food sources and lack of cover. However, amphibian, reptile, mammal and bird species commonly utilize grass flats as a portion of their habitat.

(3) Shrub Thicket Habitat

Shrub thickets generally occur in low, level areas similar to grass flats but with greater protection from salt spray and winds. Thickets are often interspersed with grass flats and sometimes occur on the lee side of well developed dunefields. Plants usually sharing dominance in this community include wax myrtle, marsh elder, silverling, Hercule's club, yaupon, and (above Cape Hatteras) bayberry and beach heather. Herbs common to the grass flats and dunefields and stunted trees common to the maritime forest frequently extend into the shrub thickets. Shrub thickets are relatively important wildlife habitats, particularly on the many barrier islands which lack significant forested areas. The dense vegetational cover is valuable to many animals, such as cottontail rabbits and migrating passerine birds.

(4) Maritime Forest Habitat

Maritime forests generally occur away from the ocean shore where the coastal winds and salt spray are somewhat reduced. These areas are well suited to development with soil absorption systems. Such forests are considered the climax vegetation for most of the North Carolina coast (Bordeau and Oosting 1959, Au 1974) and accordingly are well-developed only in areas that have been relatively undisturbed. Many of the barrier islands do not contain any significant maritime forest stands because of narrow island widths, storm destruction, burial by wandering sand dunes, fires and coastal developments (Bordeau & Oosting 1959). Barrier islands which contain sizable stands of maritime forests include Smith Island, Bogue Banks, Shackleford Banks, Hatteras Island at Buxton Woods and Bodie Island near Nags Head (Bordeau and Oosting 1959, Burk 1962, Parnell & Adams 1970, Au 1974).

Characteristic features of the maritime forests are an abundance of sclerophyllous (leathery-leaved) evergreens, vines, and epiphytes, with a relative scarcity of herbaceous plants (Johnson et al. 1974). Live oak trees are typically the most conspicuous element of this community. Other woody plant species include red cedar, loblolly pine, red bay, yaupon, wax myrtle, palmetto, American holly and Hercule's club. The significant mesic maritime forest stands are reported to occur on Bogue Banks, Buxton Woods and Nags Head Woods (Burk 1962).

These forests provide food and cover for many wildlife species and are the primary habitat for animals such as gray squirrels, bobcats and many passerine birds. The only significant population of whitetail deer on the Outer Banks occurs at Buxton Woods (Quay 1959, U.S. Fish and Wildlife Service 1980).

Figure III.4 contains a series of profiles showing the sequence of terrestrial habitats typically found on barrier islands.

(5) Protected Species

As a result of public concern about the conservation of the nation's native flora and fauna, the United States Congress passed the Endangered Species Act of 1973 (P.L. 93-205) which provides for the preservation of endangered and threatened species of wildlife, fish and plants. Endangered refers to those species which are in danger of extinction throughout all or a significant part of their range. Threatened refers to those species which are likely to become endangered within the foreseeable future throughout all or a significant portion of their range.

With regard to animals, state protection covers the same species listed by the federal government. However, the North Carolina Plant Protection and Conservation Act provides protection for other plant species in addition to the federal list. Special concern species are plants which require monitoring by the state but may be collected and sold under specified regulations.

Protected animal species known from the coastal region of North Carolina are listed in Table III.1. Habitat and distribution information is also provided for the more likely species of terrestrial habitats and coastal waters. Protected plant species known from the coastal area are listed in Table III.2.

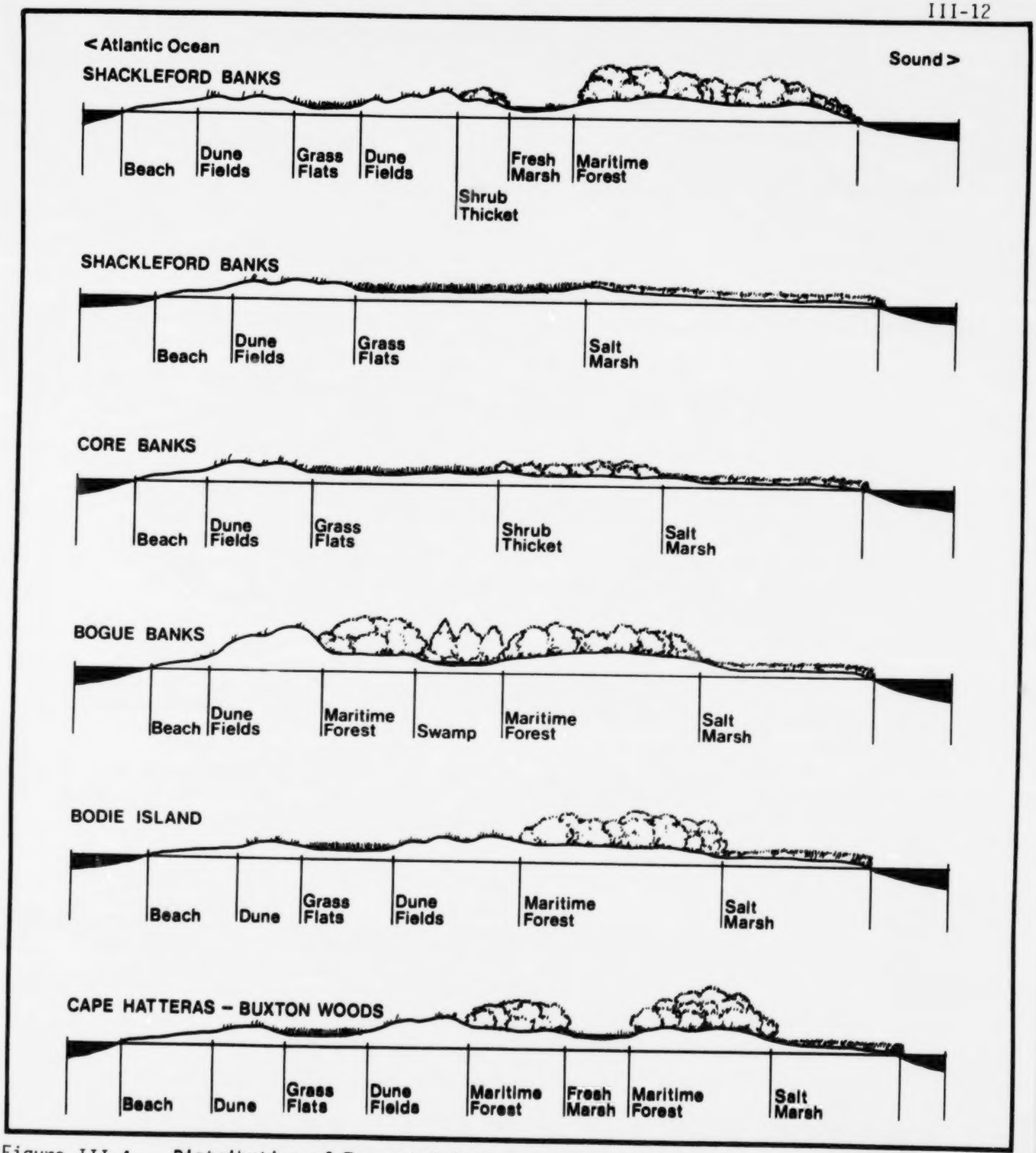

< Atlantic Ocean
Sound >
SHACKLEFORD BANKS
Beach
Dune Fields
Grass Flats
Dune Fields
Shrub Thicket
Fresh Marsh
Maritime Forest
SHACKLEFORD BANKS
Beach
Dune Fields
Grass Flats
Salt Marsh
CORE BANKS
Beach
Dune Fields
Grass Flats
Shrub Thicket
Salt Marsh
BOGUE BANKS
Beach
Dune Fields
Maritime Forest
Swamp
Maritime Forest
Salt Marsh
BODIE ISLAND
Beach
Dune
Grass Flats
Dune Fields
Maritime Forest
Salt Marsh
CAPE HATTERAS – BUXTON WOODS
Beach
Dune
Grass Flats
Dune Fields
Maritime Forest
Fresh Marsh
Maritime Forest
Salt Marsh

Figure III.4 Distribution of Terrestrial Community Types Along Representative Barrier Island Profiles.

Sources: Au, 1974; Godfrey and Godfrey, 1976; U.S.G.S. Topographic Maps.

Table III.1 Protected Animals Known from the Coast of North Carolina.

Group Common Name, (Species)	Status*	Habitat	Known Occurrence (Counties)
BIRDS			
Peregrin falcon (Falco peregrinus tundrius)	E	Near coastal waters	All coastal counties
Bald Eagle, (Haliaeetus leucocephalus)	E	Near wetlands, lakes and seacoasts	Brunswick, Hyde, Carteret, Dare
Brown Pelican, (Pelecanus occidentalis)	E	Estuarine & marine waters	Brunswick, New Hanover, Pender Onslow, Carteret, Hyde, Dare
Red-cockaded Woodpecker, (Picoides borealis)	E	Mature pine forests	Brunswick, New Hanover, Pender, Onslow, Carteret
REPTILES			
American alligator, (Alligator mississippiensis)	E	Freshwater ponds, marshes & swamps	Brunswick, New Hanover, Pender, Onslow, Carteret, Hyde, Dare
**Loggerhead turtle, (Caretta caretta)	T	Estuarine & marine waters (Nests on barrier island beaches)	Brunswick, New Hanover, Pender Onslow, Carteret, Hyde, Dare, Currituck
MAMMALS			
** Florida Manatee (Trichechus manatus)	E	Estuarine waters	Brunswick
FISH			
Shortnose Sturgeon (Acipenser brevirostrum)	E	Estuarine & marine waters	

*Status: E = Endangered, T = Threatened. Source: N. C. Natural Heritage Program.

**Other protected sea turtles and marine mammals are known to occasionally range through coastal waters; these species include the Atlantic Ridley Turtle (Lepidochelys kempii), Green Turtle (Chelonia mydas), Hawksbill turtle (Eretmochelys imbricata), Leatherback Turtle (Dermochelys coriacea), Blue Whale (Balaenoptera musculus), Finback Whale (Balaenoptera physalus), Humpback Whale (Megaptera novaeangliae), Right Whales (Eubalaena spp.), Sei Whale (Balaenoptera borealis), and Sperm Whale (Physeter catodon).

Table III.2 Protected Plants Known from the Coast of North Carolina.

Common Name, (Species)	Status*	Habitat	Known Occurrence (Counties)
Carolina spleenwort fern, (*Asplenium heteroresiliens*)	E	Calcareous sandstone & marl outcrops	New Hanover
Riverbank sandreed, (*Calamovilfa brevipilis*)	T	Freshwater marshes & bogs, savannahs	Brunswick, Onslow, Carteret
Chapman's sedge, (*Carex chapmanii*)	T	Dry sandy woods & roadsides	Brunswick, New Hanover
Sarvis holly, (*Ilex amelanchier*)	SC-E	Swamps	Brunswick, Pender
White wickey, (*Kalmia cuneata*)	SC-E	Swamps, freshwater marshes, pocossins	Pender
Carolina lilaeopsis (*Lilaeopsis carolinensis*)	T	Freshwater marshes & ponds	Brunswick, New Hanover, Dare Currituck
Rough-leaf loosestrife, (*Lysimachia asperulaefolia*)	E	Savannahs, pocossins	Brunswick, Pender, Onslow, Carteret
Loose watermilfoil, (*Myriophyllum laxum*)	T	Freshwater ponds & marshes	Brunswick, Carteret
Carolina goldenrod, (*Solidago pulchra*	E	Savannahs, pocossins	Brunswick, Pender
Spring-flowering goldenrod, (*Solidago verna*)	E	Freshwater bogs & marshes, savannahs, pine flatwoods	Brunswick
Wireleaf dropseed, (*Sporobolus teretefolius*)	T	Savannahs, pine barrens	Brunswick, Onslow
Carolina trillium, (*Trillium pusillus*	E	Moist woods	Pender
Dwarf bladderwort, (*Ultricularia olivacea*	T	Freshwater ponds & marshes	Brunswick, New Hanover, Carteret

*Status: E = Endangered, T = Threatened, SC-E = Special Concern/Endangered

Sources: N.C. Department of Agriculture; N.C. Natural Heritage Program; Radford, Ahles and Bell, 1968.

2. Surface Water Resources

The primary surface water resources directly associated with the barrier islands are the estuarine waters on the mainland side of the islands and Atlantic Ocean. Freshwater ponds are more an extension of the water table than independent surface water bodies and therefore are not identified as significant surface water resources.

Because of the importance of the resource for boating, swimming and fishing, the use of surface waters for assimilating treated wastewater is limited. The State of North Carolina prohibits the discharge of wastewaters to SA waters regardless of treatment (North Carolina Administrative Code Title 15, Chapter 2, Subchapter 2H, Section .0400). Treated wastewaters may be discharged to the ocean in accordance with regulations promulgated by the North Carolina Environmental Management Commission. Ocean discharge sites, however, may be severely limited by locally varying conditions such as the slope of the ocean bottom, depth, distance offshore and currents.

a. Water Quality Standards

Water quality standards for intercoastal and coastal waters are contained in the North Carolina Administrative Code, Title 15, Department of Natural and Economic Resources, Chapter 2, Section 0.0200. Tidal waters are classified by their intended best usage and are assigned additional water quality standard classifications to protect the defined best usage. Most of the waters in the study area are classified SA, the most stringent category. North Carolina tidal water classifications and their assigned best usages are as follows:

Classification	Best Usage
SA	Shellfishing for market purposes and any other usage specified by the SB or SC classification
SB	Primary recreation (bathing) and any other usage specified by the SC classification
SC	Fishing, secondary recreation (wading) and any other usage except for primary recreation or shellfishing for commercial purposes.

The state and federal standard for shellfish waters with respect to fecal coliform bacteria requires that

- Fecal coliform group not to exceed a median MPN (most probable number) of 14/100 ml
- Not more than 10 percent of the samples shall exceed an MPN of 43/100 ml

This standard is used as a guideline by state shellfish experts in assessing the quality of SA waters and is used to open or close shellfish beds in North Carolina.

b. Monitoring Programs

The North Carolina Department of Human Resources, Division of Health Resources, Shellfish Sanitation Office conducts sanitary and shoreline surveys of all shellfish waters once every two years. The sanitary survey is primarily concerned with identifying high bacterial counts, while the shoreline survey identifies the possible origin of such counts. If high bacterial counts are found and attributed to fecal material of humans, other warm blooded animals or waterfowl, these waters may be closed to further harvesting of shellfish until the bacterial counts can be brought under control and the threat to public health reduced.

Ambient water quality monitoring stations have been established as a means of identifying long term trends in water quality. A portion of each site is designated as a "CORE" station and is used by EPA to assess nationwide trends in water quality. Monitoring is conducted by the North Carolina Division of Environmental Management. The most frequently violated parameters noted from monitoring sites within the EIS study area include total Kjeldahl nitrogen, ammonia, total phosphorus, BOD_5, total coliform, total mercury, total lead, total zinc and total cobalt.

Additional water quality problems include decreases in salinity, increases in nutrient levels, and to a lesser degree, heavy metal violations. Decreases in salinity result primarily from mainland land use changes and reduce the productivity of primary nursery grounds and shellfish waters. Increases in nutrient levels, likewise, occur from mainland land use changes and cause algal blooms, dissolved oxygen violations, fish kills and increases in red sore disease among fish. Although heavy metals violations occur, they are not felt to be a major problem at this time.

(1) Bacterial Contamination

Because a key issue of this EIS is to determine whether water quality problems exist or are likely to exist from current wastewater practices on the barrier islands, it becomes very important to understand the origin and causes of bacterial contamination of shellfish in North Carolina. Study of the map of closed shellfish waters displayed in the Atlas indicates that in January 1981, most of the approximately 46,193 ha (114,058 ac) of closures within the EIS study area result from pollution originating from the mainland. Only 4,281 ha (10,570 ac), which represents less than 0.5 percent of the available 823,314 ha (2,032,875 ac), has been closed due to activities potentially related to barrier islands.

Although septic tanks are thought to cause contamination of barrier island waters, relatively few data are available to confirm or deny this claim. Those studies that have been made near barrier islands deal with specific locations and are of limited value for making generalizations for all barrier islands. Specific studies include work by Bane and Walker (1980), Shiver and Register (1978), and EPA (1975).

Bane and Walker were primarily concerned with pollution from marinas between Southport and Shallotte Inlet. This study concluded that marinas were contributors to coliform pollution of shellfish waters in Brunswick County. Another important finding was that increasing total and fecal coliform counts were associated with rainfall, since after rainfall, elevated bacterial counts in shellfish waters were generally observed. No attempt was made to determine the sources of this pollution other than the marinas.

Shiver and Register and EPA analyzed total and fecal coliform contamination originating from septic tanks on finger-fill canals at Surf City. Rhodamine dye studies indicated a dual transport mechanism of total coliform bacteria originating from septic tanks into shellfish waters:

- Direct transport of bacteria and other pollutants through the groundwater (surficial aquifer) to the shellfish waters
- Indirect transport overland during periods of moderate to intense rainfall (.28-.76 cm/hr) (0.11-0.30 in./hr) when rising ground water levels forced contaminated waters in soil absorption systems to the surface.

The study concluded that direct transport is of minor concern, since it appeared that the septic tank systems adequately filtered out bacteria, causing their counts to be extremely low in the groundwater, generally less than 3/100 ml for both total and fecal coliform. Under normal operating conditions, conventional septic tanks appeared to provide adequate removal of bacteria from the septic tank leachate.

Surface runoff or indirect transport of contaminated waters resulted in total coliform ranging from 22,100-240,000 MPN/100 ml and fecal coliform from 330-13,000 MPN/100 ml in shellfish waters immediately adjacent to the runoff. The Surf City study may or may not apply to other finger-fill canals along the barrier islands of North Carolina. However, studies elsewhere along the South Atlantic coast, notably Hilton Head Island, SC (EPA 1982) show surface runoff to be a major factor in the closing of shellfish waters.

The key factor in controlling bacterial contamination from drainfields in groundwater and adjacent shellfish waters appears to be the coarseness of the soil between the nitrification field and groundwater table. Fine to medium grain materials typically result in low bacterial counts in the groundwater while a medium to coarse material will generally produce higher counts (Shiver 1981). In the case of Surf City, most of the fill material was adequate to reduce ground water levels of bacteria. However, each area developed by filling in marsh must be analyzed separately in order to determine its suitability for placement of septic tanks that will adequately remove bacteria prior to the leachate's contact with the groundwater.

The second key issue is the geological/hydrogeological conditions of the site. On finger fill canals, typically a natural hardpan layer of marsh is filled in with man-made materials. "Pop outs" or "break outs" of the groundwater aquifer in such areas are typical when rain saturates the soils. The type of on-site system that functions safely under such circumstances is addressed in Appendix 3.3.2 of the Technical Reference Document, Environmental Inventory Report.

(2) Heavy Metal Pollution

Based upon studies of municipal wastewater treatment plant effluent discharges at Wrightsville Beach and Morehead City, Whaling et al. (1977) concluded that any coastal municipality discharging effluent into tidal estuaries will produce a zone of elevated toxic trace metals, especially mercury and cadmium, in the sediment and in detrital feeding organisms such as the mud snail (Ilyamassa obsoletus). Initial results indicate that no accumulation of metals occurred in the commercially important oyster, thus minimizing the public health risks. However, concern exists that lesser understood lethal or sublethal effects on environmentally sensitive organisms could occur from discharging treated effluent from municipalities into intercoastal waters. Other than this source of heavy metals contamination, which is very localized, Whaling (1981) believes the intracoastal and coastal waters of North Carolina are relatively free of heavy metals pollution.

(3) Nutrient Pollution

The primary sources of nutrient pollution in North Carolina's intracoastal waters are all related to mainland activities and include runoff as well as presently unquantified amounts of municipal and industrial wastewater discharges. The major areas affected by nutrient pollution are the Pamlico and Albemarle Sounds.

3. Groundwater Resources

Groundwater resources associated with barrier islands are derived from two different sources: the local surface aquifer and the deep confined aquifers which extend from the mainland to the ocean under the islands. The surface aquifer is a lens of freshwater under each barrier island that floats in a basin formed by the denser saltwater as shown in Figure III.5. This aquifer, replenished directly by rainfall, is easily tapped as a source of potable water but is vulnerable to contamination from saltwater intrusion, wastewater effluent and surface runoff. Several coastal locations use this resource for municipal water supplies including Ocean Isle Beach, Hatteras Island, Ocean Sands and Nags Head/Kill Devil Hills. Whalehead Beach, Currituck County, is proposing a shallow well water system. A number of non-community water systems in Dare and Carteret Counties utilize shallow well aquifers.

As county water systems become available, many of these smaller communities will connect to the county system. Use of the surface aquifer is rapidly becoming a backup system in communities such as those mentioned above and on Hatteras and Ocracoke Islands. In some cases, however, it can be assumed that the shallow well system will remain functional, and if additional water is required, it will be supplemented by regional or county water systems.

The natural quality of the groundwater on the barrier islands is variable. High dissolved solids content or tastes and odors associated with hydrogen sulfide or iron may render waters unpalatable without some treatment. Depending upon aquifer recharge and pumping demand, salt water intrusion may be a problem. Water from some public wells at Ocean Isle Beach, for example, increases in chloride content during peak seasonal demand and must be closely monitored to prevent overuse of the fresh water lens (Mulligan 1981). Salt water contamination of groundwaters also occurs naturally from overwash or high tides.

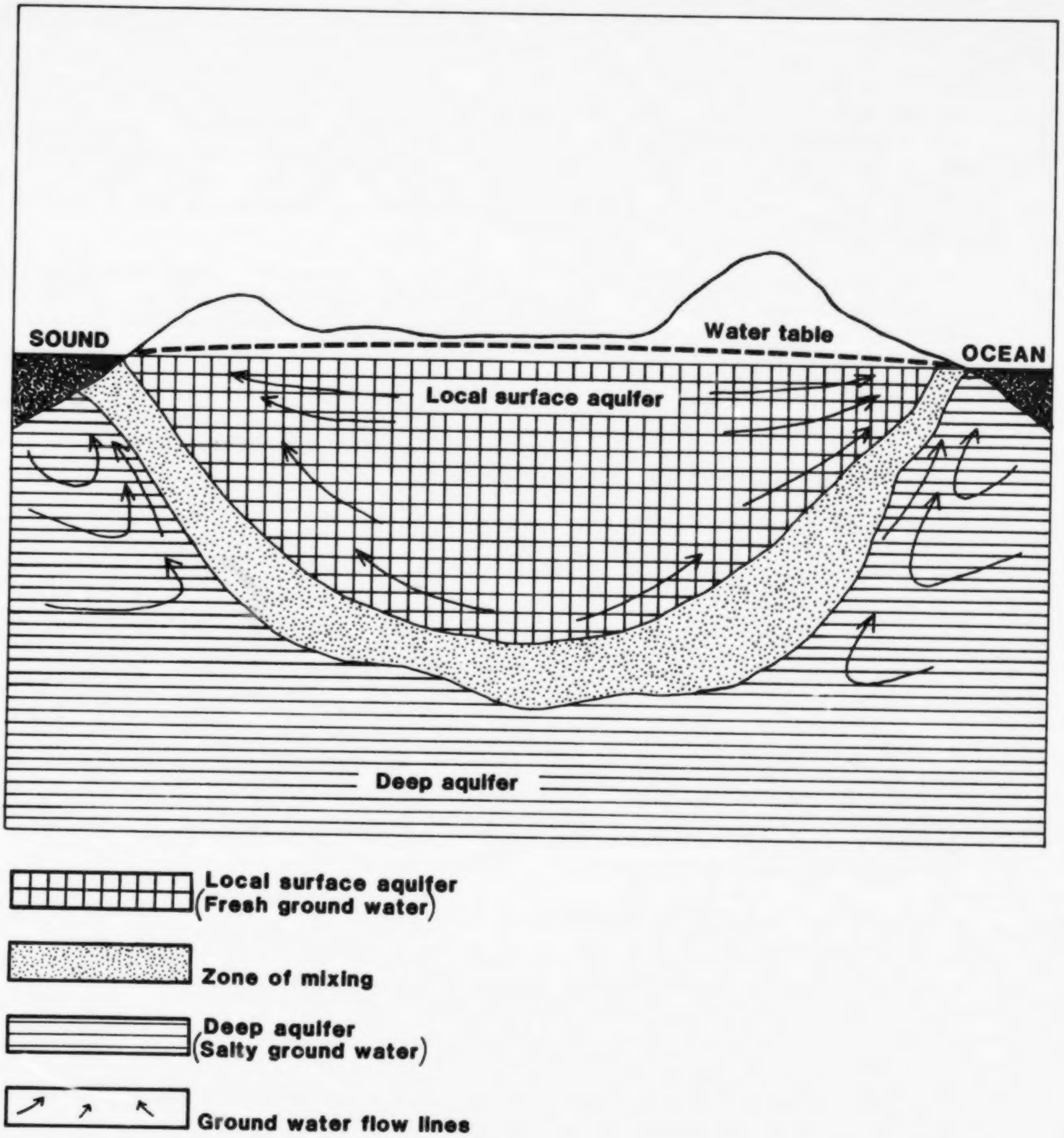

SOUND
Water table
OCEAN
Local surface aquifer
Deep aquifer
Local surface aquifer (Fresh ground water)
Zone of mixing
Deep aquifer (Salty ground water)
Ground water flow lines

Figure III.5 Cross-section of the Interaction Between the Local Surface Aquifer and Deep Aquifer.

Source: Claude Terry & Associates, Inc., 1983.

The main issue associated with groundwater quality for this EIS, however, is the potential contamination of the water table aquifer by effluent from septic tank soil absorption systems or by subsurface discharges from package treatment plants. The principal known threats to the water table aquifer from wastewater discharges are bacterial and viral contamination and nitrate contamination.

The North Carolina Safe Drinking Water Act describes the requirements for installing a water supply system and describes requirements for finished water quality parameters. It does not, however, provide requirements for raw water parameters.

Because the state has not yet assigned groundwater standards, the issue of groundwater pollution is difficult to define. Operators of wastewater treatment facilities with subsurface discharges are required to perform self monitoring of groundwaters up gradient and down gradient of the nitrification field or application site. However, generally poor location of test wells and/or deficiencies in sampling techniques have limited the usefulness of this self monitoring data (Shiver 1981). No self monitoring is required for small septic tank systems [less than 11,370 l (3,000 gal)].

4. Geological Resources

The barrier islands of North Carolina had their origin about 15,000 years ago when the sea level was 76 m (250 ft) or more below the present sea level during the last major ice age. Beach ridges (dunes) were formed by wave and wind action along the coastline, which was 80.5 km (50 mi) seaward of its present position. As the sea level rose when the continental ice sheet melted, the beach ridges were breached, and the low lying areas behind the dunes were flooded, forming lagoons or sounds; then the beach ridges became islands. With the continued rise of the sea level, the islands migrated to their present position (Pilkey, Neal and Pilkey 1978).

a. Accretion and Erosion Dynamics

In addition to continuing sea level rise, other factors that cause erosion/accretion include offshore topography, circulation patterns, waves, tides, winds, longshore current drift, nature of shoreline orientation and geometry, and storm events. The process of erosion/accretion is one of the most important aspects of barrier island geology, affecting inlet propagation and migration, overwash zones, and beach and island migration. An understanding of local erosion and accretion trends is essential when siting development and wastewater management systems.

When storms strike the North Carolina coast, changes in inlets can occur overnight, largely as a result of water pressure that builds up on the sound side of the islands. While most of these inlets change locations, they seem to fluctuate in the region of their ancestral inlets (Pierce 1970, Baker 1977). In general, the movement of inlets is from north to south following the current patterns (Hollister 1973, El-Ashry and Wanless 1968).

During storms, washover fans are formed in low-lying areas by the rising storm surge waves (Pierce 1970). The storm surge piles up along the coast, and the general movement is from the beaches into the sounds. This provides sediments necessary to allow for propagation of salt marsh areas on the sound side of these islands.

Beach and island migration is still occurring on all the barrier islands of this region. The normal pattern is for erosion to occur on the northern or eastern ends of the islands with accretion occurring on the southern or western tips of the islands (El-Ashry and Wanless 1968). Figure III.6 illustrates these processes. The rates of change range up to 6.1 m (20.0 ft) per year but average about 0.5-1.0 m (2.0-3.0 ft) per year (Bellis, O'Connor and Riggs 1975). The major factors influencing the changing barrier island formations are summarized as follows:

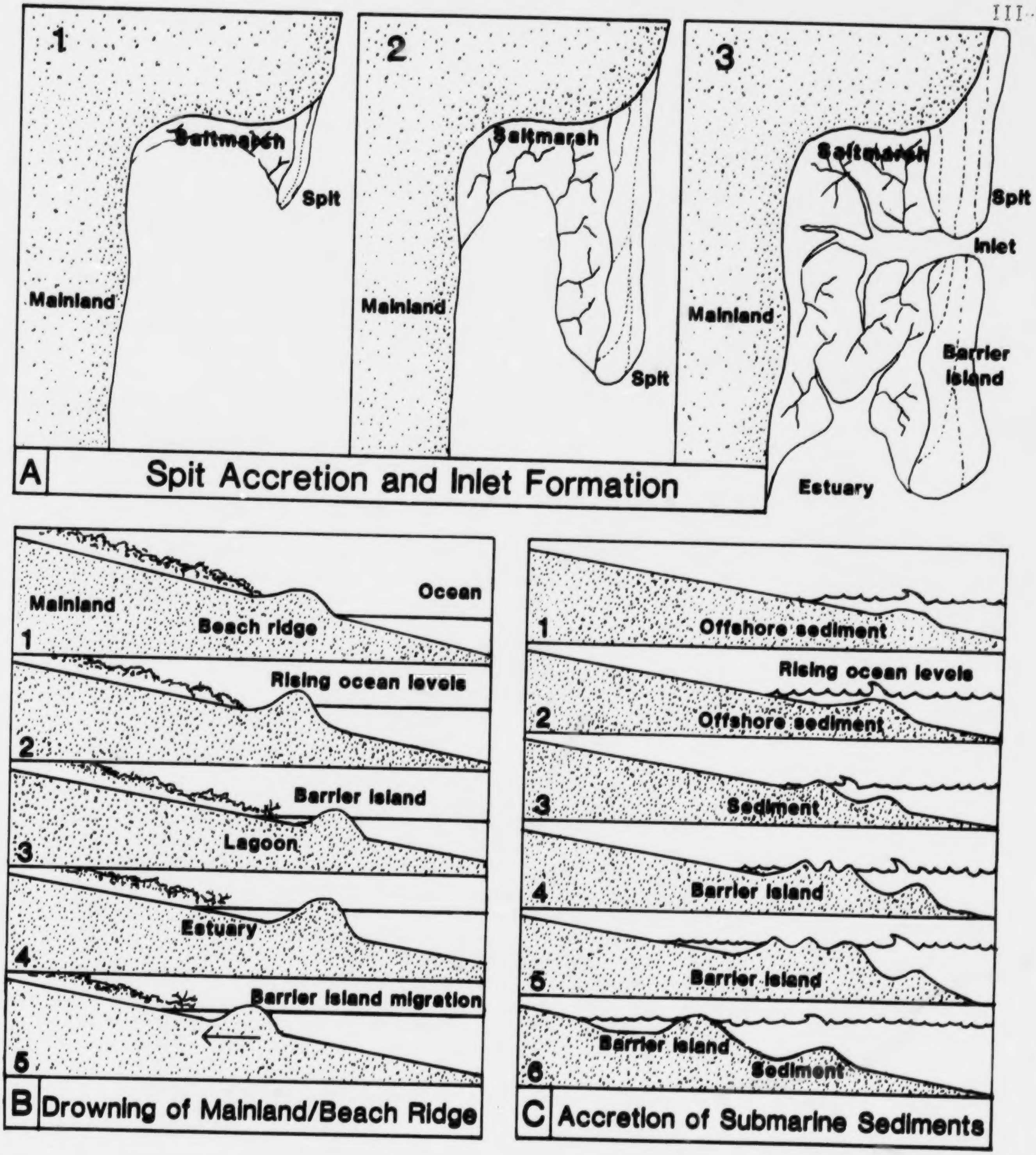
- Along the North Carolina coast, sea level is presently rising at an estimated rate of about 0.3 m (1.0 ft) per century. This results in the seaward sides of the barrier islands moving back due to beach erosion.
- On narrow, low barrier islands, the landward sides of barrier islands may experience growth when the islands are breached during storms, allowing sand to be carried into the sound by ocean currents. This can result in tidal deltas and ultimately in new land.
- Beaches may grow in a seaward direction principally by the input of new sand traveling parallel to the beach from upcurrent areas or by deposition of new sand being brought on shore by storms, typically during the summer.
- Construction of jetties to preserve beaches results in erosion of other beaches down current of the jetties.
- Improper placement of homes and other structures on dune ridges also has a destabilizing effect.

b. Topography

The topography of the barrier islands is comprised of several distinct features. The foreshore is the relatively smooth portion of the beach that extends from the normal low tide level to the normal high tide level. At the high water mark is the berm which is normally indicated by a well-marked break in slope. From this point inland to the farthest point reached by waves is the rougher but relatively flat backshore. Beyond the point where the topography is not normally affected by waves, dunes are commonly found. Behind the dunes and above the high tides are the barrier flats and higher grass which may contain stands of trees and grasslands. Between the barrier flats and above mean sea level are the salt marshes. Past the salt marshes toward the sound are the tidal flats, which are below mean sea level. Both the salt marshes and tidal flats have relatively shallow slopes.

Although island lengths are highly variable, widths are commonly less than 1.61 km (1.0 mi). Depending on their orientation to ocean currents, wave action and prevailing winds, their topography varies from that of low, narrow islands with almost no dunes to islands with high topography and extensive dune formation.

The topography is also subject to seasonal changes. During the summer the beaches are typically wider due to sand build-up by the prevailing currents that parallel the coast. During the winter and in large summer storms, wave action and strong backwash remove sand from the beaches, resulting in narrower beaches and larger offshore sandbars.


1
Saltmarsh
Spit
Mainland
2
Saltmarsh
Mainland
Spit
3
Saltmarsh
Spit
Inlet
Mainland
Barrier island
Estuary
Mainland
Ocean
Beach ridge
1
Rising ocean levels
2
Barrier island
Lagoon
3
Estuary
4
Barrier island migration
5
1
Offshore sediment
Rising ocean levels
2
Offshore sediment
3
Sediment
4
Barrier island
5
Barrier island
6
Barrier island
Sediment

A Spit Accretion and Inlet Formation

B Drowning of Mainland/Beach Ridge

C Accretion of Submarine Sediments

Figure III.6 Formation of Barrier Islands
Sources: Leatherman, 1979; Godfrey & Godfrey, 1976; Dolan, et. al., 1980.

In many developed areas, structures have either been situated on dunes or on sites where natural dunes have been removed prior to construction. These practices have resulted in destructive erosion in some cases and in frequent clean-up operations to remove sand build-up (natural dune formation). In some cases, residences and their septic tank systems on the ocean front are destroyed because there are no dunes for protection.

c. Soils

The present day barrier island soils developed from unconsolidated marine deposits or parent materials and are relatively young compared to soils found on the mainland. Soils in the dune and grassland areas are coarse textured and, for the most part, granular in structure and very well drained or excessively drained. Finer textured soils, such as clayey soils, are also found on the barrier islands in the marsh zone. Finer textured soils are shallow and contain a horizon consisting mostly of decaying organic materials and seasonally high water tables.

The Soil Survey for the North Carolina Outer Banks published by the USDA Soil Conservation Service contains maps of individual soil units on the barrier islands. The maps are inscribed on individual aerial photographs to enable location of the soil types. These mapping units are useful for determining the general suitability of an area for the construction of homes and septic tank absorption fields. Site specific evaluations are required for actual construction. Table III.3 lists soils series and their characteristics.

The Technical Reference Document, Environmental Inventory Report, contains an appendix (Rubin 1981) which analyzes barrier islands soil characteristics as they relate to the appropriate use of soil absorption systems for wastewater management. The EIS also analyzed soils in detail to determine if future population projections could be accommodated on soils suitable for the use of soil absorption systems (see Ch. II.A.2.a).

5. Sensitive Natural Areas

Sensitive areas are environmental features which warrant particular consideration for qualities such as uniqueness, rarity, hazardous conditions, high ecological value and low tolerance to disturbance. Barrier islands are considered sensitive for a number of reasons:

- -Vulnerability to storms with their associated high winds and floodwaters
- -Continual erosion and accretion processes along island shorelines
- -The presence of sensitive features such as wetlands, protected species habitats and historic sites.

Additionally, barrier islands form an important protective zone by shielding estuaries and mainland shores from the effects of storm events and normal erosional processes. Sensitive areas which are especially important to this study include ocean hazard zones, biologically productive coastal waters, wetlands, wildlife nesting areas, maritime forests and natural and cultural resource areas.

Table III.3. Soil Series and Characteristics for North Carolina Barrier Islands.

Soil Series	Flooding	Depth to Seasonal High Water Table	Permeability (in/hr)
Beach	frequent (monthly)	1.0 - 3.0'	rapid, 6.3
Leon fine sand	some surface ponding	0.0 - 3.0'	rapid, 6.3
Beach-Foredune Assoc.	frequent-rare	Beach 0.0-3.0' Foredunes 6.0'	rapid, 6.3
Bohicket, low	frequent (daily)	0 - 3.0'	slow 0.06"/hr.
Tidal flats	frequent (monthly)	0 - 3.0'	rapid 6.3"/hr.
Carteret, low	frequent (daily)	0.0 - 3.0'	rapid 6.3"/hr.
Corolla fine sand	rare to common - storm tides	1.5 - 3.0'	very rapid 20"/hr.
Corolla fine sand forested	rare - high storm tides	1.5 to 3.0'	very rapid 20"/hr.
Dredge spoil	rare - storm tides	3.0'	rapid 6.3"/hr.
Hobonny soils	frequent (monthly)	0 - 2.0'	moderate 0.63-2.0"/hr.
Duckston fine sand,	rare to common-storm tides		very rapid 20"/hr.
Duckston fine sand, forested	rare to common-storm tides	1.0 - 2.0'	very rapid 20"/hr.
Duneland	none	6.0'	very rapid 20"/hr.
Fripp fine sand	rare - storm tides	6.0'	rapid 6.3"/hr.
Levy	frequent (monthly)	0.0 - 2.0'	slow 0.06 - 0.2"/hr.
Madeland	rare - storm tides	3.0'	rapid 6.3"/hr.
Carteret, high	frequent (monthly)	1.0 - 3.0'	rapid 6.3"/hr.
Carteret	frequent (monthly)	0.0 - 3.0'	rapid 6.3"/hr.
Currituck	frequent (monthly)	0.0 - 3.0'	rapid 6.3"/hr.
Newhan fine sand	none	6.0'	very rapid 20"/hr.
Duneland-Newhan Complex		6.0'	very rapid, impervious material urban
Wando fine sand	none	6.0'	very rapid 10"/hr.
Canaby	surface ponding	0.0 - 1.0'	rapid 6.3"/hr

Table III.3 Continued

Soil Series	Flooding	Depth to Seasonal High Water Table	Permeability
Echaw fine sand	none	2.5 - 5.0'	rapid 6.3"/hr.
Kureb fine sand	none	6.0'	rapid 6.3"/hr.
Currituck, high	frequent (monthly)	0.0 - 2.0'	rapid 6.3"/hr.
Bohicket, high	frequent (daily)	0.0 - 3.0'	slow 0.06"/hr.

Source: USDA Soil Conservation Service, Soil Survey for the North Carolina Outer Banks

a. Ocean Hazard Zones

Areas affected by winds, wave action, flooding, and unstable soils are considered ocean hazard zones. Certain features which are particularly vulnerable include coastal dune systems, overwash zones, inlets and floodplains. Most of the lower elevation lands on the barrier islands occur within the 100-year floodplain. Most kinds of development are considered undesirable in floodplain areas unless precautions are taken to elevate structures above estimated storm surge levels.

b. Productive Coastal Waters

Productive coastal waters are considered sensitive areas since they are naturally high in biological productivity. These systems produce large numbers of shellfish and finfish which are important to both local commercial and sportsfishing interests.

c. Wetlands

Wetlands are communities with vegetation adapted to periodic flooding by salt water or freshwater. Because of their high ecological value and important hydrologic functions, wetlands are protected by federal and state regulations. Wetlands are vulnerable to water pollution and developments which alter the drainage characteristics of such areas.

d. Wildlife Habitat

The large number of birds which nest on the barrier islands is related to several factors: isolation, close and abundant feeding grounds, and location within the Atlantic Flyway. Important waterfowl nesting and habitat areas are primarily located in the upper sections of the Outer Banks northward of Ocracoke Island. Particularly noteworthy are the wading bird rookeries, which typically contain large assemblages of herons, egrets, ibis and related birds in dense concentrations, and two colonies of the endangered brown pelican.

Loggerhead turtles reach their northern nesting limits around Pea Island (U.S. Fish and Wildlife Service 1980). Female loggerheads generally nest several times during the summer months on the upper beaches of remote shores (Dean and Talbert 1975). Although mortality is often quite high (80-100 percent) on other Southeastern barrier islands (with eggs frequently being destroyed by raccoons, feral hogs and high storm waters), predation losses appear to be only a nominal problem on most North Carolina beaches, except on Onslow Beach and Smith Island (Crouse 1981). However, hatchling turtles may become disoriented by lights and noises near developed beaches and subsequently die from dessication before they reach ocean waters (Johnson et al. 1974).

e. Maritime Forests

Barrier islands which contain sizable forest stands include Bogue Banks, Hatteras Island and Bodie Island. Forest sites are often considered prime areas for development because they occur on upland soils in the protected interiors of barrier islands. Some types of development may be compatible with the forest community systems, providing that tree cover is not significantly reduced. Low-density housing has been constructed in forests of barrier islands such as Hilton Head, South Carolina and Saint Simons, Georgia without the excessive clearing of trees.

f. Natural and Cultural Resource Areas

Under the administration of the North Carolina Natural Heritage Program, certain sites have been placed on the North Carolina Register of Natural Areas. Such sites include environmental or natural resources of more than local significance in which non-compatible development could result in major or irreversible losses of scientific, educational and aesthetic values. Examples include sites containing remnant (threatened and endangered) plant or animal species, outstanding, rare and/or undisturbed natural communities and unique geologic formations.

A number of cultural resource sites occurring within the study area are listed on the U. S. National Register and by the North Carolina Historic Preservation Section. Known sites of historical and archeological importance are mapped in the Atlas. However, many barrier islands have not been surveyed for the existence of additional sites (Baker 1975, Hall 1981, Phelps 1981).

B. Man Made Environment

The unique natural environment of barrier islands offers numerous opportunities for recreation and development serving permanent and seasonal residents as well as tourists. However, because of the specific limitations imposed by island ecosystems, development requires special planning activities and controls.

The majority of the acreage on the barrier islands of North Carolina is undeveloped. However, the last decade has seen a significant increase in residential and tourist-related development. Problems created from rapid development include degradation of environmentally sensitive areas, traffic congestion, surface water pollution and isolated instances of groundwater contamination in finger-fill canal development areas. Along with increased development has come a rise in demand for community services, including potable water and wastewater disposal. These demands are straining the islands' environmental resources, causing aesthetic degradation and putting pressures on a relatively modest tax base.

Market trends point toward higher density development whose realization would be made possible by the provision of central wastewater treatment and disposal. In the final analysis, the quality and quantity of new development will largely depend upon the implementation of land use and environmental protection regulations. The implementation of the state/local partnership for future planning and development of coastal areas under the North Carolina Coastal Area Management Act has been slow. As a result, the nature and impact of new development on island resources remains to be decided.

1. Population

Population figures for the communities and unincorporated areas located on the barrier islands are available from many sources and vary considerably. Substantial difficulty has been encountered in accurately assessing population trends in regions that cater to tourists and leisure time activities as a major component of the communities' economic structure. Each barrier island experiences dramatic shifts in population between the summer season when vacationers flock to the shore and the winter season when only round permanent residents inhabit the remote island retreats. Often the summertime influx swells the total population to more than ten times the winter population. As an example, the permanent residents of Wrightsville Beach number 1701 during the winter season. In contrast, 25,000 people are estimated to be within the city limits on any given peak activity day such as the Fourth of July. Table III.4 shows estimates of summer peaks that are added to resident population in the 201 planning areas.

Countywide population data are available for each coastal county from 1980 U.S. Bureau of Census counts. Since 1970 the number of permanent residents inhabiting the barrier islands has increased by 86 percent, from 12,786 to 23,960 (including Manteo). This growth rate greatly exceeds the overall North Carolina growth rate of 15 percent and the coastal county growth rate of 23 percent.

Table III.5 shows population figures for permanent residents. Signifi-

Table III.4. Peak Day Population Estimates for Seasonal, Permanent and Day Visitors.

201 Planning Area	1980	1990	2000
Southeastern Brunswick County	18,322	31,770	-
Southwestern Brunswick County	13,821	15,204	16,724
Dare Beaches	35,760	50,915	71,022
Carteret County Complex	12,159	(1985) 14187	-
Topsail/Surf City	17,253	-	-
Other Calculations			
Wrightsville Beach[1]	25,544	45,746	81,924
Hatteras National Seashore[2] (average daily summer figure)	12,710	18,032	23,352

Source: [1] Development of Beach Use Statistics, Wrightsville Beach, North Carolina, U.S. Army COE, Wilmington, 1980.
[2] Cape Hatteras National Seashore, Environmental Assessment, Electric Transmission Line, 1979.

Table III.5. Permanent Population Counts and Projections for Counties and Island Communities.

	Census 1960	Census 1970	Prelim. Census 1980	1970-1980 % Incr.	EPA Estimates 1980	EPA Estimates 1990	EPA Estimates 2000	201 Plan Estimates 1980	201 Plan Estimates 1990	201 Plan Estimates 2000
Brunswick County	20,278	24,223	35,394	46	41,200	55,100	68,500	40,382	59,008	79,762
Holden Beach	-	135	224	65				230	302	360
Ocean Isle Beach	5	78	110	41				132	173	206
Sunset Beach	-	108	326	302				182	239	286
Coswell Beach	-	-	106	-				66	86	107
Long Beach	102	493	1795	264				1771	2324	2886
Yaupon Beach	89	334	558	67				721	947	1176
Carteret County	27,438	31,603	40,794	29	40,300	48,400	55,800	38,100	42,400	45,300
Atlantic Beach	76	300	724	141				660	870	1000
Emerald Isle	14	222	816	267						
Indian Beach	-	-	61	-						
Pine Knoll Shores	-	-	659	-				770	1400	1600
Dare County	5935	6995	12,401	77	11,300	16,000	22,600	10,200	14,000	2,000
Atlantic Twp.	864	1141	3741	228						
Kill Devil Hills	268	357	1760	393						
Southern Shores	-	-	425	-						
Hatteras Twp.	1217	1333	2023	52						
Kennekeet Twp.	434	565	925	64						
Nags Head Twp.	2760	3328	4881	47						
Manteo	587	547	885	62						
Nags Head	-	414	978	136						
Onslow County	86,208	103,126	112,165	9	121,300	127,600	133,200	100,700	108,000	111,400
West Onslow Beach		175	250						550	630
Pender County	18,508	18,149	22,107	22	23,600	29,300	35,500	18,700	19,900	20,300
Surf City	-	166	390	135						
Topsail Beach	-	108	245	127						

Sources: Southwest Brunswick, Southeast Brunswick, Carteret Co., Dare Beaches Complex, and the Topsail/Surf City 201 Plans.
U.S. Census 1960, 1970, 1980 Preliminary
EPA Population Projections--1980, 1990, 2000.

cant differences are found in the year 2000 projections as computed by EPA and the draft 201 Plans.

All the barrier island communities predict an increasing peak population as second home and commercial development proceeds. Also, as the median age of the U.S. population increases, more retirees are discovering the moderate climate and relaxed atmosphere of the Outer Banks and are settling as permanent residents. These trends, combined with increased leisure time for all sectors of the economy, guarantee that seasonal and day use of North Carolina's barrier islands will continue to expand. The provision of cost-effective and environmentally sound wastewater management systems is therefore a critical issue confronting local governments.

2. Land Use

The barrier islands encompass approximately 67,641 ha (167,015 ac) comprised mostly of publicly and privately owned undeveloped land. Undeveloped lands include lands held in abeyance for urban uses, beaches, marsh and wetlands, dune areas, and maritime forests. Presently, large portions of the barrier islands are owned by the federal government, with Cape Hatteras National Seashore and Cape Lookout National Seashore representing the largest single parcels. Public acreages will increase further should the proposed federal purchase of most of Bodie Island in Currituck County be realized. More than 8,505 ha (21,000 ac) are developed throughout the barrier islands.

While these statistics appear to indicate that large portions of the islands are relatively untouched, trends show they are experiencing considerable development pressures and increased usage. According to the Heritage Conservation and Recreation Service, the percentage of developed land in the barrier islands increased from 3.9 percent in 1950 [approximately 2,390 ha (5,900 ac)] to 13.9 percent in 1974 [approximately 8,748 ha (21,600 ac)]. This information was based on a survey of aerial photograephy conducted by the U. S. Geological Survey.

Development pressures have been directly related to accessibility from the mainland and availability of privately owned vacant lands. Most development has occurred in and around the islands' incorporated towns. Development has taken the form of residential growth accompanied by tourist related business. Only on that portion of Bodie Island located in Currituck County has development progressed slowly because of access problems.

The development pattern characteristic of most beach communities is a linear strip running parallel to the beach front. Most lots are long and narrow. Usually, the greater development density occurs on the beach side and diminishes with distance from the beach. The majority of developed acreage is in residential uses with seasonal housing usually exceeding permanent housing. Seasonal housing types range from cottages to duplexes and mobile homes. Commercial uses are generally scattered along major roads.

The amount of industrial land use is negligible. The absence of a large labor force, adequate transportation routes and large plots of land, plus environmental constraints, limit industrial development. Most of the remaining developed acreage is dedicated to municipally owned buildings, churches and educational facilities.

3. Development Controls

Through a hierarchy of federal, state and local regulatory mechanisms, coastal developers must consider the impact of proposed construction activities on various economic, social and environmental resources. Those statutes and regulations which affect the provision of wastewater management services are discussed below.

a. Federal Controls

The Coastal Barrier Resources Act (CBRA), signed into law on October 18, 1982, establishes the Coastal Barrier Resources System. This system consists of undeveloped coastal barriers located on the Atlantic and Gulf coasts of the United States. The CBRA prohibits the expenditure of most new federal financial assistance within the units of the system. This includes new federal grants for wastewater facilities that would support future growth.

Additional information is available in 43 CFR Subtitle A, Interpretive Guidelines and General Statement of Policy (47 FR 52388). Maps showing the undeveloped barriers included in the system are available for inspection in North Carolina at the Pea Island National Wildlife Refuge in Rodanthe and the U.S. Fish and Wildlife Service offices in the Federal Building in Raleigh. Figure III.7 is a general map showing the location of these areas in North Carolina. Figures II.22 through II.27 show units of the system that are included in the six 201 planning areas. Other federal actions significantly affecting the development of barrier islands are listed below. Descriptions of the law, its effects and associated authorities are presented in the Technical Reference Document, Environmental Inventory Report.

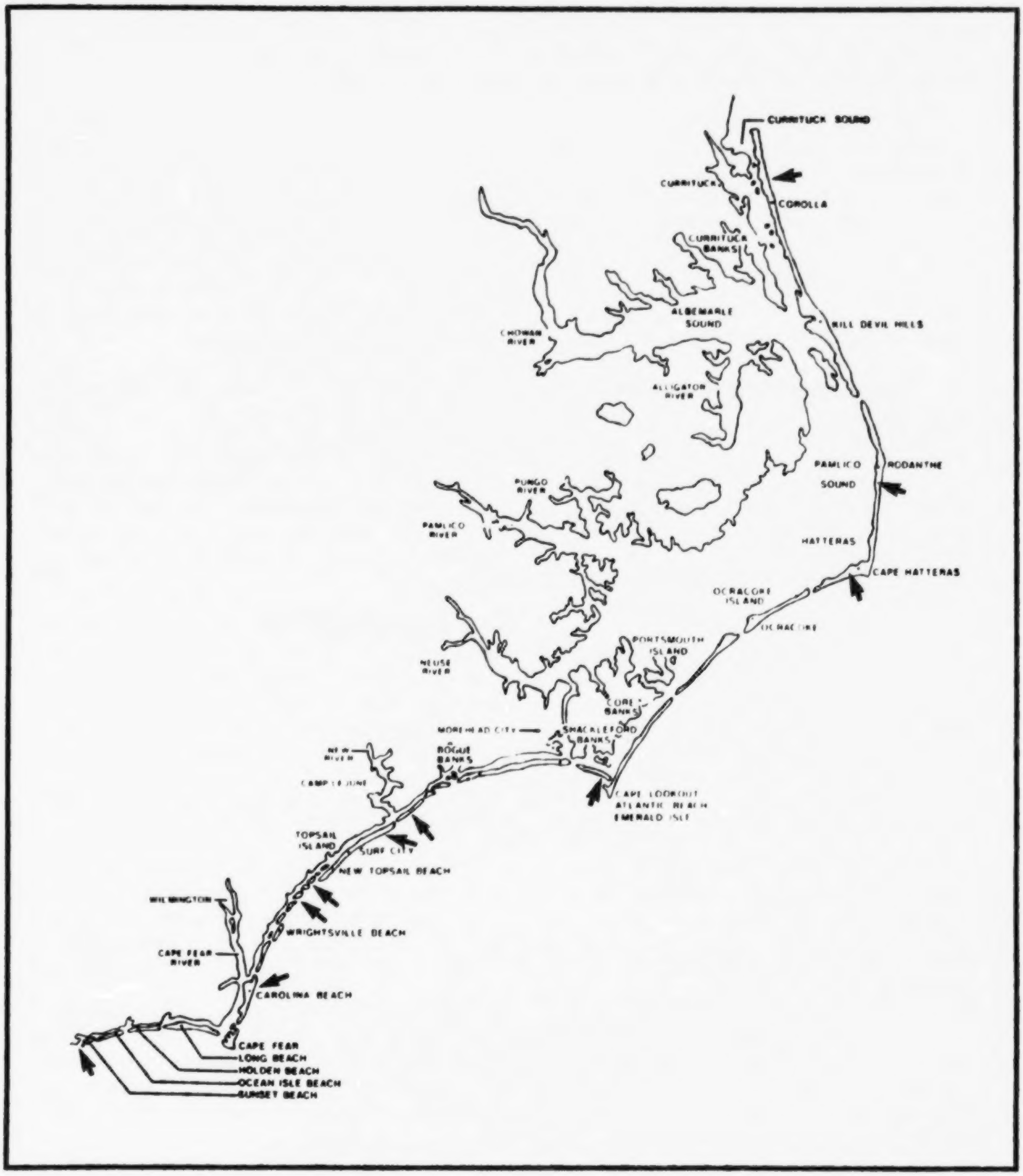
- National Environmental Policy Act
- National Flood Insurance Program
- Clean Water Act
    - National Pollutant Discharge and Elimination System (Sec. 402)
    - Dredge and Fill Permits (Sec. 404)
- Threatened and Endangered Species Act
- Coastal Zone Management Act.

b. State Controls

Since most natural resources extend beyond the jurisdiction of local governments, the state has developed regulations that set minimum standards for utilization of resources. Examples of these resources include water supplies, land and land cover, and renewable food resources such as shellfish. While the state administers many aspects of the natural resource base, two primary areas of regulatory control directly affect barrier islands: coastal management and wastewater treatment.

(1) Coastal Management Program

The passage of the North Carolina Coastal Area Management Act (CAMA) in 1974 demonstrated the state's strong and continued interest in establishing a comprehensive, coordinated approach for the protection, preservation and orderly development of the state's coastal resources. Resource management activities are distributed among different state agencies, as well as different levels of government. These lines of responsibilities cover all


CURRITUCK SOUND
CURRITUCK
COROLLA
CURRITUCK BANKS
ALBEMARLE SOUND
KILL DEVIL HILLS
CHOWAN RIVER
ALLIGATOR RIVER
PAMLICO SOUND
RODANTHE
PUNGO RIVER
PAMLICO RIVER
HATTERAS
CAPE HATTERAS
OCRACOKE ISLAND
OCRACOKE
PORTSMOUTH ISLAND
NEUSE RIVER
CORE BANKS
MOREHEAD CITY
SHACKLEFORD BANKS
NEW RIVER
BOGUE BANKS
CAMP LEJEUNE
CAPE LOOKOUT
ATLANTIC BEACH
EMERALD ISLE
TOPSAIL ISLAND
SURF CITY
NEW TOPSAIL BEACH
WILMINGTON
WRIGHTSVILLE BEACH
CAPE FEAR RIVER
CAROLINA BEACH
CAPE FEAR
LONG BEACH
HOLDEN BEACH
OCEAN ISLE BEACH
SUNSET BEACH

← Indicates Protected Area

Figure III.7. Areas Protected Under the Coastal Barrier Resources Act.

aspects of environmental management, from controlling destruction of sand dunes to regulating the placement of septic tank absorption fields.

In 1977, Governor Hunt signed Executive Order 15 mandating state agency consistency between the local land use plans and the North Carolina Coastal Management Plan (CMP). The State Guidelines contain policies adopted by the Coastal Resources Commission that serve as the framework for the development of the local land use plans, establish the standards for Areas of Environmental Concern and represent the overall state policy on coastal issues. The local land use plans further define these state policies by applying the policies contained in the Guidelines to local situations. Consistency of local actions with state policies is promoted because of the required approval of the local plans by the Coastal Resources Commission.

The North Carolina program uses two major criteria to determine the potential impact of any given activity: the location of the use in relation to coastal waters and the character of the use. That is, there are certain areas in the coastal zone in which almost any use has the potential to directly affect coastal waters while in other areas only large scale activities significantly affect coastal waters. In order to administer the CMP in an equitable and politically consistent manner, 20 counties were included under CAMA jurisdiction to control direct and significant impacts on coastal waters. These counties are shown in Figure III.8.

The critical areas in the North Carolina coastal zone are identified as Areas of Environmental Concern (AEC). The Coastal Resources Commission has determined which types of areas should be presently designated as AECs and has established standards for development in those areas. All but a few exempted activites must receive a permit to develop in these areas and must therefore comply with the appropriate standards. The four major AEC classifications are: Natural and Cultural Resource Areas, Public Water Supplies, Ocean Hazard Areas, and the Estuarine System. These are described in detail in the Technical Reference Document, Environmental Inventory Report.

All of the AECs combine to create a zone that includes all estuarine waters and coastal wetlands and a narrow buffer zone of land around them. Figure III.9 is a diagram of a typical coastal area delineating AECs. This zone is the area where strictest regulation is deemed necessary and therefore, where the CAMA permit letting process applies to practically all development.

Estuarine System. Included within the estuarine system are the following AEC categories: Estuarine Waters, Coastal Wetlands, Public Trust Areas and Estuarine Shorelines. Each of these AECs is either geographically within the estuary or, because of its location and nature, may significantly affect the estuary.

Ocean Hazard Areas. The next grouping is composed of those AECs that are considered natural hazard areas along the Atlantic Ocean shoreline where, because of their special vulnerability to erosion or other adverse effects of sand, wind and water, uncontrolled or incompatible development could unreasonably endanger life or property.

Public Water Supplies. Public water supplies as a broad category includes two AECs: Small Surface Water Supply Watersheds and Public Water Supply Well Fields.

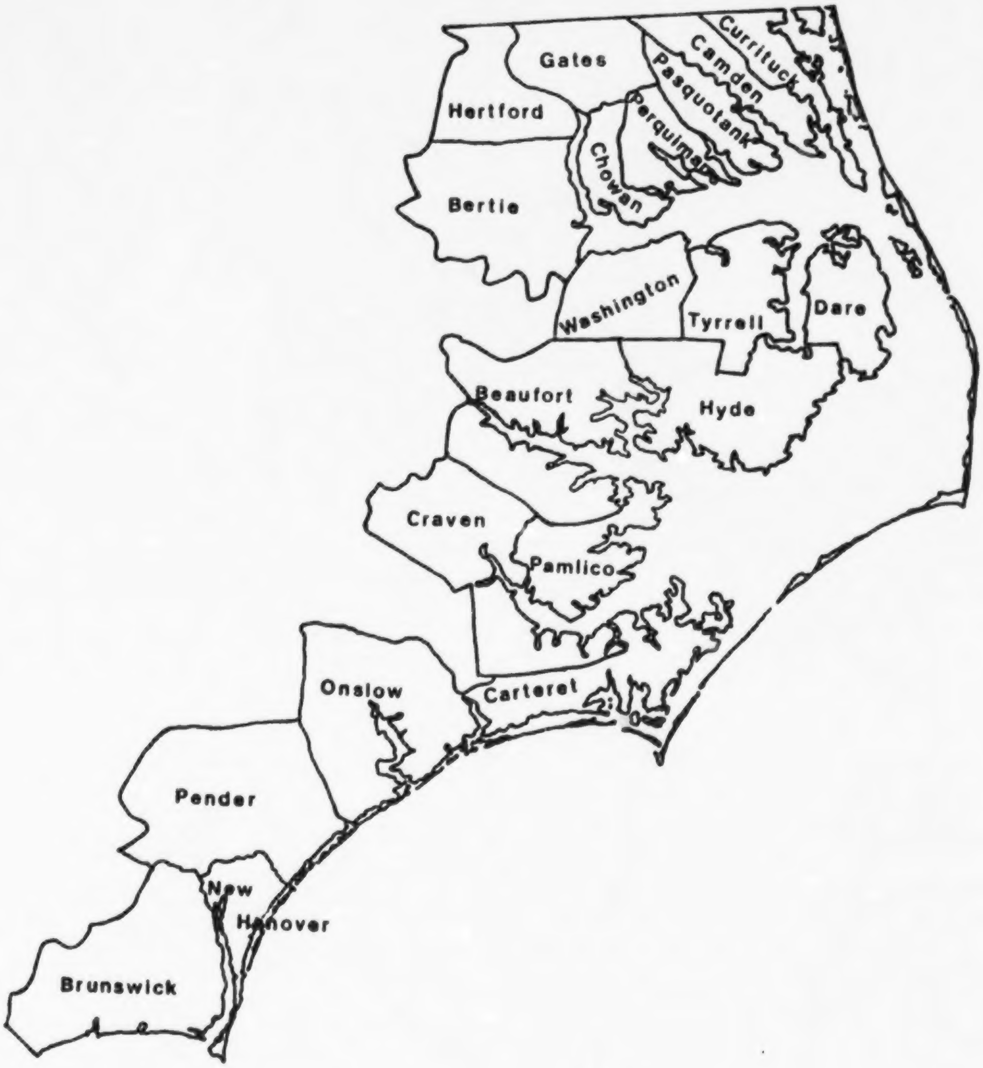

Gates
Currituck
Camden
Pasquotank
Hertford
Perquimans
Chowan
Bertie
Washington
Tyrrell
Dare
Beaufort
Hyde
Craven
Pamlico
Onslow
Carteret
Pender
New
Hanover
Brunswick

Figure III.8 Map of North Carolina Coastal Zone
Source: U.S. Department of Commerce;
N.C. Department of Natural Resources and Community Development

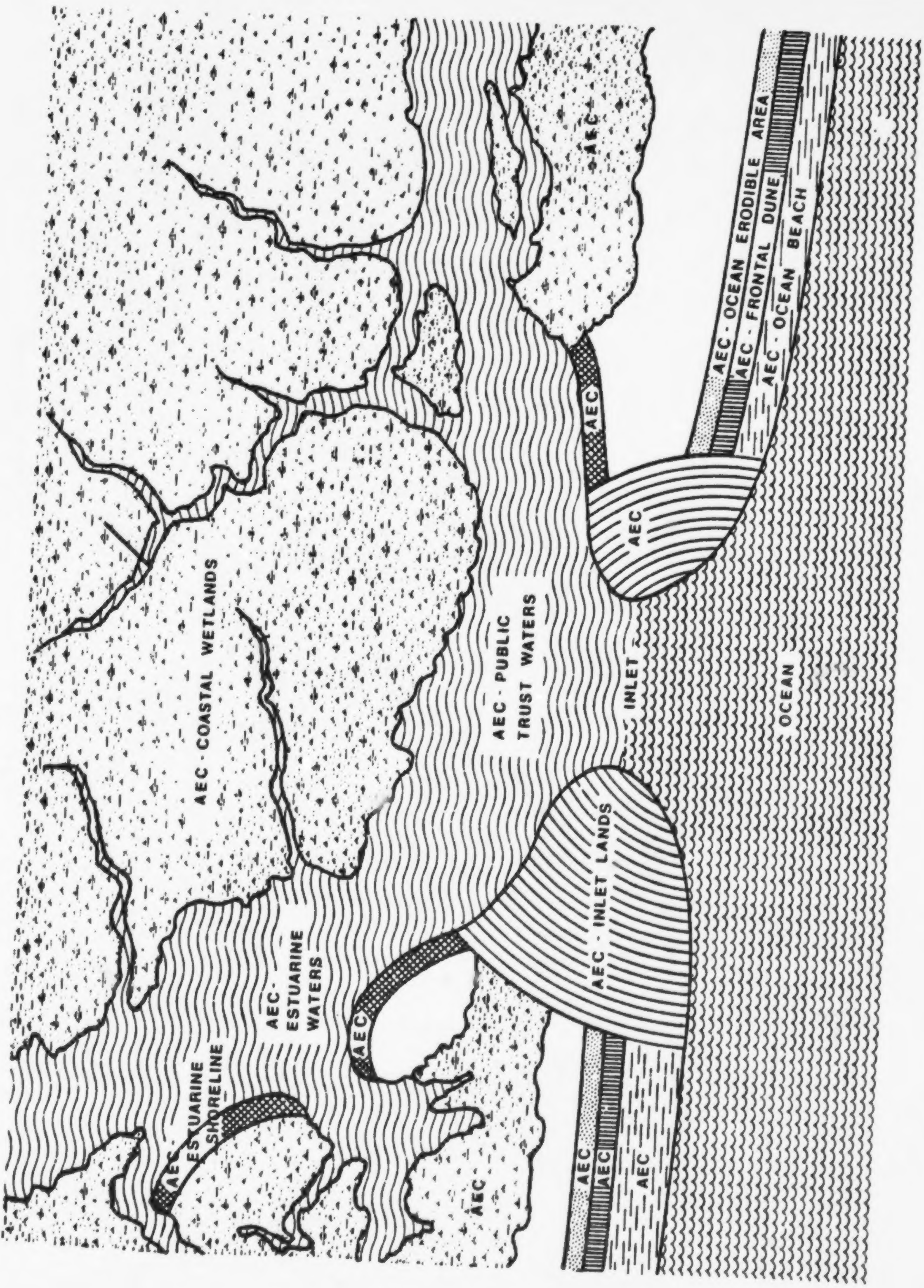

AEC · OCEAN ERODIBLE AREA
AEC · FRONTAL DUNE
AEC · OCEAN BEACH
AEC
AEC
AEC
AEC · COASTAL WETLANDS
AEC · PUBLIC TRUST WATERS
INLET
OCEAN
AEC · INLET LANDS
AEC
AEC · ESTUARINE WATERS
AEC · ESTUARINE SHORELINE
AEC
AEC
AEC
AEC
AEC

Figure III.9 Generalized Description of Areas of Environmental Concern
Source: U.S. Department of Commerce;
N.C. Department of Natural Resources and Community Development

Fragile Coastal Natural Resource Areas. The final group of AECs is defined as areas containing environmental or natural resources of more than local significance in which uncontrolled or incompatible development could result in major or irreversible damage to natural systems, scientific or educational values or aesthetic qualities.

The authority to designate AECs rests exclusively with the Coastal Resource Commission. However, once these areas are designated, the authority for administering the CAMA permit program is shared between the CRC and local government units within the coastal area.

In coastal areas outside AECs, the Coastal Management Program relies on a more limited role. The state is involved in decision-making in non-AEC areas only when uses and activities which have a potential for directly and significantly affecting coastal resources are proposed.

Figure III.10, entitled "Critical Uses/Authorities Matrix," identifies the regulations that are applicable to each of the critical (permissible) uses included under North Carolina's management plan. Several of the authorities are applied to certain types of areas, rather than to specific uses. Therefore, all uses in those certain areas are subject to regulation unless they are exempted by the authorizing legislation or agency regulations. The most important of these regulated areas are groundwater capacity use areas, floodways, sand dune protection areas and wetlands subject to dredge and fill regulations (U.S. Dept. of Commerce 1978).

(2) Wastewater Management

Currently, the responsibility for permitting the installation of systems using land or surface water disposal is that of the North Carolina Department of Natural Resources and Community Development, Division of Environmental Management. Installation of such systems is also subject to DNRCD's regulation governing coastal wastewater treatment and disposal (North Carolina Administrative Code Title 15, Chapter 2, Subchapter 2H, Section .0400). Permitting the installation of subsurface disposal systems is the responsibility of the local county health department under the Department of Human Resources, Division of Health Services regulation (North Carolina Administrative Code Title 10, Chapter 10, Subchapter 10A, section .1900). Revisions to the N. C. Laws and Rules for Ground Absorption Sewage Treatment and Disposal Systems became effective July 1, 1982. The document covers engineering standards, soils criteria, site evaluation procedures, user permits, effluent application rates, and systems design criteria. In addition, more stringent local regulations may be adopted by County Boards of Health.

c. Local Controls

County health departments play a major role in wastewater management on barrier islands since the EIS study area communities are largely served by on-site soil absorption systems or small community systems with subsurface disposal. County health departments are responsible for implementing the state regulations mentioned above. As such, they provide system design, site evaluation, inspection and permitting services. These functions are significant determinants on where current and future development takes place.

NORTH CAROLINA AUTHORITIES TO CRITICAL USES

ADMINISTERING AGENCY	Department of Natural Resources and Community Development																							Dept. of Administration		
	DEM	DEM	DEM	DEM	DEM	DEM	DEM	DEM	DEM	DEM	DMF	DMF	DMF	DMF	DLR	DLR	DLR	DLR	DPR	DPR	DPR	DPR					
STATUTORY AUTHORITY (G.S. CITATION)	143-215.1	143-215.11	143-215.39	143-215.51	143-215.75	143-215.105	87-87	162A-20	162A-26	143-355	113-229	113-230	113-201	113-205	143-215.23	74-48	113-381	113A-50	113-34 et. seq.	113A-30	113A-83	113-29 et. seq.		143B – 437	146-6 (c)	146-3 et. seq.	146-22.1
AUTHORITIES / CRITICAL USES	Water Quality Control Statutes	Water Use Act	Federal Water Resources Development Act	Floodway Regulation	Oil Pollution Control Act	Air Quality Statutes	Well Construction Act	Regional Water Supply Planning Act	Regional Sewage Disposal Planning Act	Development & Improvement of Harbors	Dredge & Fill Act	Wetland Production Orders	Fisheries Statutes	Registration of Grants in Navigable Waters	Dam Construction Act	Mining Act	Oil & Gas Conservation Act	Sedimentation Pollution Control Act	Acquisition and Management of State Parks	Natural & Scenic Rivers Act	N.C. Trails System Act	Acquisition & Development of State Forests		Investigation of Impact of New & Expanded Industry	Easements To Fill	Easements, Leases, Sale of State Land	Acquisition of Land for Public Purposes
Petroleum Refineries	X			X	X	X					X	X					X	X						X	X		
Energy Generating Facilities	X			X		X					X	X					X	X						X	X		
Oil and Gas Wells	X			X	X	X	X				X	X					X	X							X	X	
Mining Operations	X	X		X		X	X				X	X				X								X	X	X	
Major Petroleum Storage Sites	X			X	X						X	X					X	X							X		
State Roads											X	X						X							X	X	
Bridges											X	X						X							X	X	
Commercial Ports	X		X		X	X				X	X	X						X						X	X	X	
Navigation Projects	X		X								X	X		X													
Industrial Parks	X			X		X					X	X						X						X			
Shopping Centers	X			X							X	X						X						X			
Large Subdivisions	X			X		X					X	X						X									
High Rise Apts. or Hotels	X			X							X	X						X									
Manufacturing Facilities	X			X		X					X	X						X						X			
Livestock Feedlot Operations	X										X	X															
Pesticide Use																											
Large Drainage Operations	X										X	X															
Large Water Wells	X	X					X	X			X	X															
Sewage Treatment Facilities	X								X		X	X						X									
Public Drinking Water Supplies		X					X	X			X	X															
Solid Waste Disposal Sites						X					X	X						X							X		
Large Marinas	X		X								X	X													X		
State Parks											X	X							X	X	X					X	X
State Forests																				X	X	X				X	X
Preservation of Natural and Scenic Rivers																			X	X							
Preservation of Historic Properties																			X								X
Public Accessways											X	X														X	X
Large Dams			X								X	X			X											X	
Commercial Fishing												X	X														

B

DPR			Dept. of Adminis tration			Dept. of Agriculture	Dept. of Commerce		Dept. of Cultural Resources	Dept. of Human Resources			Dept. of Transpor- tation			DMF
113-29 et. seq.		143B – 437	146-6 (c)	146-3 et. seq.	146-22.1	143-434	62-110	143-217	121-9	130-166.22	130-166.17	130.161.1	136-44.1	136-66.2	136-122	113-251
Acquisition & Development of State Forests		Investigation of Impact of New & Expanded Industry	Easements To Fill	Easements, Leases, Sale of State Land	Acquisition of Land for Public Purposes	Pesticide Application	Public Utilities Act	State Ports Authority	Acquisition & Management of Historic Properties	Ground Absorption Sewage Disposal Act	Solid Waste Disposal Act	Sewer & Sanitation Act	Highway Safety Act	Streets & Highways in and Around Municipalities	Roadside Advertising	Atlantic States Marine Fisheries Compact
		X	X													
		X	X				X									
			X	X												
		X	X	X												
			X													
			X	X									X	X	X	
			X	X												
		X	X	X				X								
		X								X	X	X				
		X								X	X	X				
										X	X	X				
											X	X				
		X								X	X	X				
						X										
												X				
												X				
			X								X					
			X							X	X					
				X	X											
X				X	X											
					X				X							
				X	X											
				X												
																X

KEY TO SYMBOLS:
(Abbreviations represent Division with Dept. of NR & CD)
Responsible for program administration

DEM–Div. of Env. Management
DLR – Div. of Land Resources
DMF–Div. of Marine Fisheries
DPR–Div. of Parks & Recreation

Figure III.10
Critical Uses/Authorities Matrix
Source: U.S. Department of Commerce;
N.C. Department of Natural Resources
and Community Development

BARRIER ISLANDS E.I.S.

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV

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Prepared by:
CLAUDE TERRY & ASSOCIATES, INC. ATLANTA, GA.
GANNETT FLEMING CORDDRY AND CARPENTER, INC

Zoning and subdivision regulations are two other major local development controls. Those ordinances and a series of other typical controls are included in Table III.6 which shows which controls are in place in each 201 study area.

Conventional zoning is normally used to control the use of land and structures thereon, as well as for more detailed regulation concerning the area of the lot which may be developed (setbacks and separation of structures), the density of the development (minimum lot sizes, etc.) and the height and bulk of buildings and other structures. The general purpose of zoning is to avoid undesirable side effects of development by segregating incompatible uses and by maintaining adequate standards for individual uses.

Subdivision regulations control the process of converting raw land into building sites. They establish standards for public improvements, including streets, drainage pipes, sewer outlets, etc. These standards may be enforced by requiring developers to post performance bonds.

All North Carolina cities are authorized to have a building inspection department and must appoint building inspectors, electrical inspectors, plumbing inspectors and other inspectors as appropriate to enforce state and local laws relating to 1) the construction of buildings and other structures; 2) the installation of such facilities as plumbing systems, electrical systems, refrigeration systems and air-conditioning systems; 3) the maintenance of buildings and other structures in a safe, sanitary and healthful condition; and 4) other matters that may be specified by the city council. Counties are also required to establish building inspection departments on a phased basis to be completed by 1985.

4. Institutional and Fiscal Profile

Although both counties and cities, as well as various other entities, have the legal capacity for financing and management of services such as wastewater treatment, very few of the agencies within the 201 planning areas have become involved in such systems. Only Manteo in Dare County and Southport in Brunswick County are operating wastewater systems at this time; each provides service primarily to the population within its municipal boundary.

Many of the coastal communities do, however, provide water supply, treatment, and/or distribution to their residents. Of the four counties included in this study, only Carteret County does not have a centralized water system. Onslow County is currently completing expansion of its water system to serve all populated areas. Many of the incorporated towns in the study areas also provide water service (which may include supply and treatment or in some cases distribution only), usually within their corporate boundaries and possibly to some neighboring areas. In many cases, most of the outstanding debt of the entity is water system debt, which is usually of the general obligation bond type supported by revenues from the water system. Of the entities which have water systems, their financial reports indicate that they maintain them as separate enterprise funds, which are self-supporting, with revenues derived primarily from system fees and charges. Therefore, the experience gained in operating water systems, which entails maintaining a separate fund, establishing utility charges, and assuring that the system can support itself, should be transferable to the task of operating central or on-site/small community systems.

Table III.6. Existing Local Land Development Controls.

Jurisdiction	Zoning Ord.	Subdivision Regulations	Building Codes	Septic Tank Regulations	Erosion & Sediment Control Ord.	Trailer Camp Reg.	Flood Hazard Ord.	Mobile Home Reg.	Water Course Modification Regulation	Environmental Impact Statement Ord.	Federal Flood Ins. Program
Brunswick County	-	-	X	X	-	-	-	-	-	-	E
Long Beach	X	X	-	X	-	-	X	-	-	-	R
Holden Beach	X	X	-	X	-	-	-	X	-	X	R
Caswell Beach	X	X	-	X	-	-	X	-	-	-	R
Sunset Beach	X	-	-	X	-	-	X	-	-	-	R
Ocean Isle	X	X	-	X	-	-	-	-	-	-	R
Yaupon Beach	X	X	-	X	-	X	-	X	-	-	R
Southern Shores	X										
Carteret County	X	X	X	X	-	-	-	X	-	-	R
Emerald Isle	X	X	-	X	X	-	-	-	-	-	R
Pine Knoll Shores	X	X	-	X	-	X	-	X	-	-	R
Atlantic Beach	X	X	-	X	-	-	-	-	-	-	R
Currituck County	X	X	X	X	-	-	-	-	-	-	E
Dare County	X	X	X	X	-	-	X	-	-	-	R
Nags Head	X	X	-	X	X	-	X	-	-	-	R
Kill Devil Hills	X	X	X	X	-	-	-	-	-	-	R
Manteo	-	-	X	X	-	-	-	-	-	-	R
Hyde County	-	-	X	X	-	-	-	-	-	-	E
New Hanover County	-	X	X	X	-	-	-	X	X	-	R
Wrightsville Beach	X	X	-	X	-	-	-	-	-	-	R
Carolina Beach	X	X	-	X	-	-	X	-	-	-	R
Kure Beach	X	-	-	X	-	-	-	-	-	-	E
Onslow County	X	X	X	X	X	-	-	-	X	-	E
Pender County	-	-	X	X	X	X	-	-	-	-	E
Topsail Beach	X	X	-	X	-	-	-	-	-	-	R
Surf City	X	-	-	X	-	X	-	X	-	-	R

Source: N.C.CAMA Plans

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Tables III.7 and III.8 display revenues, expenditures and tax data for study area communities. The county data reveal wide variations among the four counties in per capita levels of assessed valuation, revenues, expenditures and debt. For example, Brunswick County's per capita assessed valuation is $48,000, while Onslow County's is $8,000. Although Onslow's population is about three times that of Brunswick, its total assessed valuation is just over half as much.

Per capita revenues and expenditure levels vary widely, indicating possibly a disparity in the range and/or levels of services provided by the various counties. On an individual basis, each county's expenditures were largely in line with its revenues in 1979-80, although Carteret County spent slightly more than it took in, probably drawing on funds carried over from previous years. Brunswick and Onslow Counties each showed a surplus of revenues of about $1 million which would most likely be carried over for the next budget year.

The major source of revenue for most cities and counties in North Carolina is the property tax; these revenues average about 60 percent of total operating revenues (excluding utility revenues) for most barrier islands communities, as compared with a statewide average of 40 percent for 62 North Carolina municipalities (Vogt 1978). Property tax rates in the selected counties vary from $ 0.47 per $100 of assessed valuation in Brunswick (1979-80) to $ 0.93 per $100 in Dare County (budgeted for 1981-82); the average for 20 North Carolina counties is $ 0.75. The higher tax rates seem to occur in the counties which have lower assessed valuations, which may reflect different revaluation schedules. When municipal property taxes are added to county levies, the total never exceeds $1.50 per $100 of assessed valuation. If taxes are less than 1 percent of market value, probably some margin exists for additional taxing; 1-2 percent is considered average; and over 2 percent is usually felt by taxpayers to be excessive.

While all counties depend upon the same sources of general revenue, the extent to which they draw upon the various types varies considerably. In Onslow County the property tax is about 45 percent of total revenues and local sales tax is 16 percent, whereas in Brunswick County, property tax makes up about 71 percent and sales tax amounts to 9 percent of the total. This implies varying degrees of dependence on the other, less significant sources of revenues. Onslow County derived 23 percent of its total from state and federal grants, which are likely to decline in coming years. The value of examining the sources of a government's operating revenues is to ascertain the degree to which it depends on sources which are not controlled locally, the availability of which may be limited or constrained by external factors.

Barrier islands communities have a higher average per capita level of revenues at $567 than the average of 62 selected North Carolina municipalities at $337 (Vogt 1978). High revenues per capita in this area reflect the high assessed valuation relative to permanent population.

Expenditure levels, which for the most part are in line with revenues for individual towns, reflect the need for a community whose population swells with the influx of seasonal visitors to provide services beyond what may be

Table III.7. Comparative Fiscal Data from Study Area Counties.

Data for Fiscal Year 1979-1980	Brunswick County	Carteret County	Care County	Onslow County
Population (Permanent)[1]	35,394	40,794	12,401	112,165
Assessed Valuation: Total (000,000's)	$1,683	NA[3]	$361	$866
Per Capita (000's)	48		29	8
Gen. Govt. Revenues: Total (000's)	10,998	6,176	5,102	12,323
Per Capita	311	151	411	110
Gen. Govt. Expenditures: Total (000's)	9,926	6,205	5,102	11,135
Per Capita	280	152	411	99
General Long-Term Debt: Total (000's)	16,875	8,288	NA	8,013
Per Capita	477	203		71
Property Tax Rate Per $100	.47	NA[3]	.93	.64
Tax Collection Ratio	95%	NA[3]		94%
Revenues as % of Total:				
Property Tax	71%	61%	68%	45%
Local Option Sales Tax	9%	16%	14%	16%
Other Taxes[4]	1%	5%	4%	6%
Grants	14%	9%	5%	23%
Other Revenues	5%	9%	9%	10%

1. 1980 Preliminary Census
2. Data for Dare County was drawn from the 1981-82 Budget, thus is not comparable with that of the other counties.
3. Carteret County's Audit Report did not contain this information.
4. Includes primarily Intangible, ABC, Privilege taxes.

Source: Claude Terry & Associates, Inc. 1981.

Table III.8. Comparative Fiscal Data from Selected Study Area Municipalities.

	(In Brunswick County)			(In Carteret County		(In Dare County)		(In Onslow County)	
Data for Fiscal Year 1979-1980	Holden Beach	Long Beach	Sunset Beach	Atlantic Beach	Pine Knoll Shores	Kill Devil Hills	Nags Head	Surf City	Topsail Beach
Population (Permanent)[1]	224	1,795	326	724	659	1,760	978	390	245
Assessed Valuation: Total (000's)	$54,390	$110,332	$32,171	$55,165	$47,024	$73,186	$84,901	$30,939	$36,024
Per Capita (000's)	243	61	99	76	71	42	87	79	147
Gen. Govt. Revenues: Total (000's)	154	685	117	461	196	748	885	218	186
Per Capita	688	382	359	637	297	425	905	559	759
Gen. Govt. Expenditures: Total (000's)	151	704	83	416	195	767	869	209	210
Per Capita	674	392	255	575	296	436	889	536	857
Gen. Long-Term Debt: Total (000's)	1,100	2,900	500	1,678	345	950	670	262	347
Per Capita	4,911	1,616	1,534	2,318	524	540	685	672	1,416
Property Tax Rate per $100	.20	.41	.24	.60	.20	.53	.52	.48	.34
Tax Collection Ratio	98%	96%	99%	93%	100%	97%	89%	93%	99%
Revenues as % of Total: Property Tax	71%	68%	64%	44%	48%	52%	48%	66%	65%
Local Option Sales Tax	9%	9%	6%	12%	15%	12%	4%	7%	8%
Other Taxes[2]	7%	8%	17%	14%	13%	10%		8%	7%
Grants	4%	4%	4%	6%	3%	11%	34%	6%	6%
Other Revenues	9%	11%	9%	24%	21%	15%	14%	13%	14%

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[1] Preliminary 1980 Census

[2] Includes primarily Franchise, Intangibles, ABC, Privilege

ordinarily demanded by the permanent population. A wide variation is found among the nine towns depicted in Table III.8 from $295 per capita expenditures in Sunset Beach to $889 in Nags Head. This disparity probably reflects different local environments, such as seasonal population influx or response to demands for additional or higher levels of services.

All of the towns have outstanding long-term debt, which in almost all cases was incurred for the provision of water supply and/or treatment systems. Most communities have used general obligation bonds to finance their water systems. The bonds are paid back almost exclusively with water revenues, with the tax base providing a fall-back position. Per capita debt levels are generally higher for the towns than for the counties.

In an area with substantial absentee ownership and an economy based largely on recreation and seasonal visitors, several implications for communities planning on making a major investment to provide wastewater treatment need consideration. Facilities must be sized to accommodate the needs of the peak population, which in turn bears directly on the cost of the system. A major issue, then, is who will benefit and who will bear the costs? Critical points in a fiscal analysis include:

- Only permanent residents (not second-home owners) have voting rights. Any issues relating to system financing or implementation which require voter approval (such as a general obligation bond issue) are therefore determined by the year-round population, who are only a fraction of those who are affected by system decisions.

- Although the economy is recreation and tourist-oriented, local governments do not necessarily derive direct financial benefits from these activities. Sales tax, after being returned to the county based on point of origin, is then allocated to incorporated towns according to their permanent population or their percentage of total county property tax revenues. This suggests that resort towns may not receive returns commensurate with their level of economic activity.

- The property tax most directly reflects the resort economy, since second-home and commercial property owners must pay taxes to the local entity. This resource would be relied upon, for example, in the case where insufficient system revenues were generated to pay back a general obligation bond issue for a wastewater system. However, should a town provide service to areas outside its corporate limits, it could not recover wastewater management revenues based on property taxes from those users.

- Various users will receive different degrees of benefit from the system, and cost impacts may vary accordingly. The cost burden for single-family year-found residents may differ from that of second-homes, rental units and lodging and commercial uses, which create varying demands on the system.

5. Economic Profile

The economy of the barrier islands depends on its land and water resources. Preservation of these resources by financially and environmentally sound wastewater management practices should be a major objective.

The tourist industry provides the majority of employment opportunities, with the commercial fishing and construction industries generating most of the remaining jobs. Island-based manufacturing employment is comparatively small and includes seafood preparation and concrete manufacturing. This economic pattern is true to a lesser extent on those islands in Carteret, Onslow, Pender, New Hanover and Brunswick Counties where close proximity to mainland urban concentrations provide access to a broader range of job opportunities.

Retail trade and services account for most jobs in the tourist industry. This sector is characterized by small businesses with low productivity. Skills and wages are low, and there are often more jobs for women than men. Annual personal incomes for 201 planning areas ranged between $4,897 and $6,101 in 1978, in contrast to the statewide average of $6,640 (N. C. Bureau of Economic Analysis, Regional Economics Information System, 1979).

Unemployment rates reveal dramatic seasonal fluctuations that are characteristic of an economy based on the recreation industry. Since most of the retail and service establishments are tourist-oriented, most residents depend upon the mainland for major retail outlets and professional services.

Industrial activity is not expected to become an important part of the barrier islands' economy due to the lack of a large, skilled labor pool, adequate transportation routes, and large tracts of land. Development restrictions caused by the fragile conditions of coastal areas also discourage industrial development. Most of the revenues from farming originate on the mainland and contribute only in a small way to the island economy. Both industry and farming provide some employment to island residents who commute to the mainland in search of work.

Retail sales and the tourist industry are expected to grow and to continue to dominate the islands' economy. This forecast is based on projected increases in incomes and leisure time and a growing market area population. This overwhelming reliance on recreation as a primary source of income leaves the barrier islands' economy extremely vulnerable to national economic conditions and weather.

The future of economically important activities that rely on natural resources such as commercial and sport fishing and waterfowl hunting will depend on proper management, control of estuarine pollution and proper land use planning to minimize habitat destruction. Duck and geese hunting, sport fishing and commercial fishing provide a major source of income. During the 1978-79 season, an estimated 108,000 hunter days were brought in $1.5 million in income to professional guides and an additional $3-4 million in general revenue. It is estimated that 1.5-2.0 million angler days are spent sport fishing in the estuarine waters of North Carolina. Additionally, professional tournament fishing and charter boat fishing bring in millions of dollars in revenue to the barrier island economy each year.

Six major commercial intracoastal fisheries are located along the barrier islands of North Carolina: oyster, bay scallop, clam, blue crab, shrimp and fin fish. Revenues derived from these fisheries are shown in Table III.9.

The total value to the economy in 1979 of all fish landed in North Carolina was $146.0 - 175.0 million. The sustained yields of both the estuarine and open water fisheries depend largely on limiting pollution of estuarine nursery grounds in North Carolina and adjacent states.

Table III.9. North Carolina Intracoastal Fisheries Revenues.

Fishery	Revenue
Oysters	$ 2.3 - 2.8
Bay Scallops	1.3 - 1.5
Clams	11.0 - 13.0
Blue Crabs	12.0 - 14.0
Shrimp	16.0 - 19.0
Southern Flounder	2.5 - 3.5
Croaker, Spot and Gray Trout, Drum	10.0 - 12.0
Total	$51.5 - 65.8

Source: Claude Terry & Associates. 1981.

6. Community Services

As development and greater usage of the barrier islands continue, the demand for services and facilities will grow. Wastewater management is only one of these critical services. The costs of increased services sized for the seasonal population may place an undue burden on the year-round population. This problem is further compounded by the large number of day users who utilize the services provided but avoid the costs of those services by not staying overnight or eating in a restaurant. Thus, much of the service costs attributable to day users will be borne by property owners.

Police, water supplies and garbage collection are generally a direct responsibility of towns on the barrier islands. Schools and health care facilities are primarily county functions and are generally located on the mainland. Counties also operate landfills for municipal solid waste agencies, and county sheriffs offices provide supplemental police protection. Fire and rescue squad protection are performed by voluntary organizations. During peak season, most towns increase their police complement, the number of garbage collections, rescue squads, and beach maintenance services. Wrightsville Beach, Carolina Beach and Kure Beach have central wastewater treatment and disposal service in all or parts of their jurisdictions. The remainder of the barrier islands are served by on-lot disposal. Table III.10 indicates the existing services provided by barrier island communities. When compared to suggested minimum community standards, police, fire and solid wastes disposal services exceed minimum requirements.

Table III.10. Existing Community Facilities and Services Associated with Barrier Islands

Jurisdiction	Municipal Sewer	Municipal Water	School Facilities	Fire Protection	Police Protection	Rescue Operations	Solid Waste Disposal	Recreation Facilities	Health Care
Brunswick Co.	-	X	X	-	X	-	X	X	X
Long Beach	-	X	-	Volunteer	X	Volunteer	X	X	-
Holden Beach	-	X	-	Coop. Arrang.	X	-	X	-	-
Caswell Beach	-	X	-	Volunteer	-	Volunteer	X	-	-
Sunset Beach	-	X	-	Volunteer	-	Volunteer	X	-	-
Pender County	-	-	X	-	X	-	X	-	X
Topsail Beach	-	X	-	Volunteer	X	Volunteer	X	-	-
Surf City	-	X	-	Volunteer	X	Volunteer	X	-	-
Carteret County	-	X	-	Volunteer	-	Volunteer	X	-	-
Emerald Isle	-	X	-	Volunteer	X	Volunteer	-	X	-
Pine Knoll Shores	-	X	-	Coop. Arrang. Arrangement	X	-	X	X	-
Atlantic Beach	-	X	-	Volunteer	X	Volunteer	X	-	X
Dare County	-	X	X	Volunteer	X	-	X	X	X
Nags Head	-	X	-	Volunteer	X	-	X	-	-
Kill Devil Hills	-	X	-	Volunteer	X	-	X	-	-

Source: CAMA Plans

X Municipal service provided
- Municipal service not provided

Groundwater is essentially the only supply of freshwater on the barrier islands. The threat of salt water intrusion at high pumping rates or long durations limits freshwater yield. Although few public water systems use the shallow water table aquifer, this aquifer provides water supply to almost all individual wells and small water systems.

Higher yield wells on the islands obtain water from the uppermost confined or semi-confined layers of the upper sandy aquifer. This is especially true inland on the peninsulas and on Roanoke Island, the site of the well field for the Dare County water system.

On barrier islands south of Beaufort Inlet, adequate water supply is not generally a limitation to development. Most public water supplies obtain water from deep wells tapping the limestone aquifer. On many barrier islands, however, the extreme seasonal fluctuations in population make it difficult for state and local officials to determine whether water supplies are limited. State officials partially circumvent this problem by maintaining records of all wells constructed by seasonal and permanent residents. Communities are required to notify state officials before a well can be constructed (Rundgren 1983, Berkowitz 1983). If adequate supplies are not available on these barrier islands, wells can be drilled on the mainland for supply water. A number of coastal counties are developing county-wide water systems which tap the deep aquifer.

As off-island public water supply systems expand and the number of individual shallow wells in the water table aquifer is reduced, the possibility of contaminated water supplies from on-site wastewater disposal systems will likely decrease. However, in some areas of the barrier islands, individual wells will continue to be the primary source of water until local legislation requires a tap-on to a municipal, county or regional water supply. In addition, private wells will be used for watering lawns and other purposes after a public supply is available.

Automobile access to North Carolina barrier islands is readily available along most of the 495.9 km (308 mi) shoreline. The North Carolina Department of Transportation is responsible for the operation and maintenance of 17 bridges and causeways serving barrier islands. The State also operates five ferry routes that provide auto access to areas where bridges are not feasible. Several private ferries operate between Carteret County and the Cape Lookout National Seashore under National Park Service permits.

The most extensive public beaches in North Carolina are maintained by the National Park Service. The Cape Hatteras National Seashore encompases approximately 121 km (75 mi) of beach frontage and includes several camping and parking areas with adequate access to the beach. The Cape Lookout National Seashore includes an additional 89 km (55 mi) of beach frontage, but at this time has limited ferry service and public facilities.

The State of North Carolina also operates and maintains several state parks and recreation, historic, and natural areas on the barrier islands. Masonboro Island and Bald Head (Smith) Island are two natural barrier islands partially owned by the state. Public access to these islands is not restricted; however, access is limited to private boats. Total beach frontage in these five areas is approximately 36.2 km (22.5 mi). Three additional state-operated areas, Carolina Beach State Park, Theodore Roosevelt Natural Area and Jockey's Ridge State Park, provide limited sound frontage on the barrier islands.

An inventory of local public access points and related facilities was prepared by the state's Office of Coastal Management. This inventory indicates approximately 522 local public access points, 107 private and commercial access points, and approximately 34 boat access points. Approximately 14 public and private fishing piers are also located along the North Carolina coast. Most public access points consist of streets with public rights-of-way extending to the ocean. Table 3.4.2 of the Technical Reference Document, Environmental Inventory Report, lists the available access points and related facilities along the barrier island beaches in North Carolina.

CHAPTER IV. ENVIRONMENTAL EVALUATION AND MITIGATIVE MEASURES

The impacts of the three wastewater management approaches developed in this EIS are identified in this chapter. In addition, measures are identified which could mitigate adverse impacts resulting from the implementation of these strategies. Finally, irreversible and irretrievable commitment of resources and energy requirements are addressed.

A. Evaluation of Impacts

Impacts on the natural and manmade environments are discussed under the categories of environmental impacts, costs, development potential and implementability.

1. Environmental Impacts

The barrier island environment will be impacted under all strategies. The aquatic, terrestrial and manmade environment will be modified by the projected population growth. The critical differences among the strategies in terms of environmental impacts are how well the strategies can adapt systems to local conditions to eliminate or mitigate potential impacts and to what extent the strategies support local planning and control to minimize potential impacts.

The EIS process has identified four major areas of impact: surface water, groundwater, sensitive natural areas and land uses. This section discusses the environmental impacts of the strategies on these areas and provides a summary of issues, existing conditions and impacts. A detailed description of existing conditions on the North Carolina barrier islands is contained in the Technical Reference Document, Environmental Inventory Report. The impacts of the three strategies may be primary or secondary, positive or negative, and can range from mild to severe.

a. Surface Water

A major issue of the EIS is the impact of alternative strategies on the surface waters associated with the North Carolina barrier islands. It is difficult to overemphasize the resource value of the coastal surface waters. They provide recreational opportunities for boating, swimming and sport fishing. In addition, they support a large commercial fishing industry based on shellfish and finfish populations. Another primary consideration is the importance of the estuarine systems' dynamics and the dependence of many ocean finfish on the system.

The State of North Carolina has recognized the importance of the coastal waters near barrier islands by classifying most of them as shellfish waters (Class SA) and prohibiting the discharge of wastewaters regardless of treatment level. The use of surface discharges is therefore largely restricted on barrier islands. However, even with the most stringent water use classification, there are still major water quality problems in coastal surface waters. Approximately 46,170 ha (114,000 ac) of shellfish waters within the study area are currently closed to harvesting. Areas of concern include bacterial contamination, nutrient levels and heavy metal contamination. However, most of these problems appear to be generally associated with mainland activities such as land use changes, specific coastal areas such as marinas or discrete environmental phenomena such as flocks of migratory waterfowl.

Few cases have been documented of surface water pollution directly attributable to barrier islands wastewater management practices. A study of nutrient pollution resulting from man's use of the barrier islands was conducted at Surf City, North Carolina (EPA 1975, Shiver and Register 1978). The study concentrated on identifying pollution from septic tanks located on finger-fill canals. This study found that nitrogen compounds, total phosphorus and total organic carbon exceeded background counts in groundwaters and surface waters in proximity to the septic tanks. Contamination of the groundwater is attributed to the fact that the septic tank drain field was placed directly into the aquifer. Little or no separation was found between the nitrification field and the groundwater table, and adsorption of nutrients by soil particles was very poor (Shiver 1981).

The 201 Strategy (as it affects barrier islands) proposes one discharge to the Cape Fear River and two ocean outfalls. It is possible that some surface discharges would also occur under the No Federal Action Strategy or the EIS Strategy. State regulations prohibit discharges to SA waters but do permit discharges to SC (fishery use) waters where adequate assimilative capacity can be documented. However, few future point source discharges are expected since few waters near barrier islands are classified SC. Due to costs, the number and volume of discharges would also be expected to be few. Current water quality standards would be expected to be met under all three strategies.

Degradation of surface water resources by urban runoff is an increasingly serious problem on barrier islands. Development has produced documented negative impacts on shellfish beds bordering several southeastern barrier islands. In some cases these impacts, initially attributed to point source discharges, have been shown to be due to nonpoint sources. A significant nearby example is Hilton Head Island, SC (USEPA, Gannett Fleming Corddry and Carpenter, Inc. and Claude Terry & Associates, Inc., 1981).

b. Groundwater

A major issue associated with groundwater on the barrier islands is the potential contamination of shallow groundwater resources by on-site wastewater management facilities. Additional concerns include the potential impacts from land application sites, increased surface runoff and salt water intrusion.

The major value of groundwater is as a potable water supply. Groundwater is essentially the only on-island supply of freshwater for the barrier islands. However, groundwater is not generally a limiting resource south of Beaufort Inlet. Most public water supplies are obtained from the deeper limestone aquifer or from deep inland wells on the mainland in this southern area. Use of the barrier island surface aquifer for potable water purposes is not widely practiced, and instances of public water supply contamination by on-site systems have not been recorded on the North Carolina barrier islands. For example, Ocean Isle Beach, which uses the surface aquifer for part of its supply, has not shown any public health problem associated with septic fields in the area. Since ultimate disposal of treated wastewater is to the groundwater for most systems under all strategies, groundwater quality and quantity remains a major issue in the EIS. However, if the probable use for the surficial aquifers on barrier islands is not potable water supply, the significance of the introduction of nitrates, bacteria and virus into the aquifer must be re-examined.

The EIS and NFA Strategies will result in continued discharge to groundwater. With the EIS Strategy, use of upgraded surface and subsurface land disposal should reduce impacts of existing discharges to groundwater. An on-site management agency and the local health department could promote future systems being installed and managed properly. In addition, an agency or health department could detect and eliminate or upgrade existing sources of contamination. In areas where on-site systems are not suitable, the EIS Strategy will provide for the use of small community systems or other off-site disposal.

Current treatment and disposal practices would be expected to continue under the NFA Strategy. The major difference between the NFA and the EIS Strategies is the lack of federal money to correct existing problems. New state regulations which became effective July 1, 1982, should resolve most if not all septic tank problems.

The 201 Strategy would reduce the use of on-site systems on the barrier islands and provide for significant portions of the flows to be discharged to surface waters or to the mainland. This alternative would provide less opportunity for localized degradation of groundwater on the barrier islands. The 201 Strategy could also lead to higher concentrations of bacteria, nitrates and viruses around sprayfields. These sprayfield sites would have higher effluent loading rates per acre than on-site systems on the barrier islands with a potentially much more significant effect on groundwater resources.

The quantity of groundwater is influenced by many factors including recharge from precipitation and effluent disposal and withdrawal for potable water use. In areas which use the surface aquifer as the potable water supply, the use of on-island land disposal techniques helps maintain the level of the aquifer. In areas where off-island water supplies are utilized, the use of on-island land disposal techniques can lead to a net gain in aquifer recharge.

This net addition could possibly result in physical contact between the water table and the bottom of drain field trenches in marginal installations causing septic tank soil absorption system malfunctions. This potential adverse impact was evaluated by applying the methodology described in Section 4.2.2.3 of the Technical Reference Document, Alternatives Development Report, to a hypothetical barrier island case study. The procedures, climatic and hydrogeologic data and important underlying assumptions used in the case study are presented in Appendix D. The results from the study show that the response of the water table to wastewater disposal can be estimated and used to evalute the potential for water table contact with drain field trenches across a given section of island. The case study analysis indicates that this situation is not likely to be extensive and occurs only for very marginal installations.

c. Sensitive Natural Areas

A number of environmentally sensitive features occur on the barrier islands of North Carolina. A primary issue considered by this study is the potential imapct of the three strategies on these sensitive areas, including ocean hazard zones, biologically productive coastal waters, wetlands, wildlife nesting areas, protected species, maritime forests, designated natural areas and significatn historic/archeological sites. These features warrant particular consideration for qualities such as uniqueness, rarity, hazardous conditions, high ecological value and low tolerance to disturbance.

Environmentally sensitive areas have been discussed in detail in the Technical Reference Document, Environmental Inventory Report, along with the existing regulatory and legal structures which currently provide protection for some of these areas. These structures include the EPA 404 permit program, the National Pollutant Discharge and Elimination System, the National Environmental Policy Act of 1969, North Carolina Environmental Policy Act of 1977 and the North Carolina Coastal Area Management Act. While some protection is provided by this framework, there are many environmentally sensitive areas which are not protected from private development. It is not possible for any of the strategies to provide blanket protection to these areas. However, the three strategies do vary in the amount of flexibility and control they could conceivably exercise to protect these areas.

Primary impacts to sensitive areas could occur during construction of wastewater management systems. The installation of collection systems, interceptors, ocean outfalls and septic tank drainfields could cause adverse impacts without careful siting of development and implementation of mitigative measures. Secondary impacts of growth in the form of increased urban runoff pose a greater danger to sensitive natural areas, however.

The 201 Strategy will provide for an increase in the number of centralized systems which use surface discharges or mainland disposal systems. The centralized systems will promote higher density development in limited areas. This will generally mean that fewer acres of land will be converted. However, this development can be expected to concentrate in or near sensitive areas (for example, maritime forests, ocean front and estuarine fringe) and could have severe adverse impacts on these areas. Additional examples of localized, severe, adverse impacts include finger-fill canals, nonpoint source discharges to freshwater wetlands, encroachment or destruction of protected species and wildlife habitat and induced loss of shore areas to shorebirds from human presence.

The NFA Strategy and the EIS Strategy will lead to lower densities per developed acre and therefore more acres will undergo development to serve the projected population. This assumes the increase in population to be the same with and without a central/regional system. Such low density development may lead to low level degradation of the sensitive areas. For example, low density housing has been constructed in forests on barrier islands such as Hilton Head, South Carolina and Saint Simons, Georgia without the unnecessary clearing of trees. Neither of the strategies will guarantee the protection of the environmentally sensitive areas. In fact, long term adverse impacts are anticipated to several environmental features under all strategies. The NFA Strategy will not provide for the correction of current problems nor will problems nor will it provide for improved procedures in the future. No additional control would be available to protect sensitive areas. However, the EIS Strategy would provide for the possible protection of many categories of environmentally sensitive areas through the planning process. The planning and management functions of the EIS Strategy would provide the necessary framework to correct existing pollution problems and avoid or mitigate future impacts.

d. Land Use/Population

Land use and development densities will interact with projected population levels in several ways. It is generally assumed by state and local officials that the same numbers of persons will be attracted to the North Carolina barrier islands regardless of what type wastewater management systems are provided. Higher residential densities with accompanying lower housing unit costs would likely result from the provision of central/regional systems. Although a given prospective purchaser might refuse to pay the higher housing costs of low density development, market demand in higher income brackets may be adequate to absorb the projected number of units proposed by developers under the EIS and NFA Strategies.

The second land use/population impact is the increase in urban runoff that will result from future development regardless of which strategy is implemented. Although the volumes generated are similar under all three strategies, the effects will probably differ. The 201 Strategy would promote the highest population densities per developed acre; hence, localized urban runoff problems are more likely to arise under this strategy. The potential impacts would be secondary, adverse and long term. The NFA and EIS Strategies would lead to lower density developments and less concentrated urban runoff would be anticipated. If the citizens of the area desire a management agency, this agency could serve to promote these best management practices.

e. Other Resources

Adverse impacts to other resources of the natural and man-made environments are either largely insignificant under all three strategies or basically identical (showing no incremental differences). These resources are discussed below.

No effects are anticipated on climate or air quality levels. Proper systems operations will eliminate odor problems. Construction noise is temporary.

Alterations to terrain are expected to be negligible under all three strategies. Original contours will be restored after construction. Properly installed and maintained soil absorption systems and land surface disposal systems are not expected to produce adverse impacts on soils.

Impacts to aquatic ecosystems are included in the discussion of surface water quality impacts.

Impacts to terrestrial ecosystems are included in the discussion of sensitive natural areas.

Because population levels will not differ significantly under the three strategies, the communities' economic profile and demand for community services will be approximately the same.

2. Costs

Financial impacts have been a major area of concern in this EIS. Local financial bases are small, and questions have been raised by EPA and by local officials and citizens about the ability of island communities to bear the capital and operation and maintenance costs of central/regional wastewater management systems. The EIS explored the costs and local financial burden of a variety of on-site and small community soil absorption systems which might be alternatives to systems proposed by the draft 201 Plans.

Costs of the five proposed 201 Plan wastewater systems were compared in Table II.19. The affordability of these systems was shown in Table II.20 which contains the typical household monthly charge for each 201 Plan. Only the user charges for the 201 Plans in Topsail/Surf City, Carteret County and Dare Beaches are affordable, assuming 75 percent EPA funding and 12.5 percent state assistance toward eligible costs.

In order to assess the financial impacts of various alternative systems, the EIS analyzed a case study of a hypothetical barrier island in North Carolina. Various wastewater management systems were designed for the island based on the implementation of the three strategies: No Federal Action, 201 and EIS Strategies. Implementation of the Carteret County draft plan was used to illustrate the 201 Strategy. Two scenarios, low and medium density development, were carried out under the EIS Strategy.

Costs were presented for each scenario on the basis of present worth costs and average monthly costs for a typical household. These cost comparisions are shown in Table IV.1. Table II.11 showed that the EPA user charge ceiling guideline figures ranged from $18.74 to $24.82. Comparing this range to the charges shown in Table IV.1 which shows that all scenarios appear affordable except the draft 201 Plan when no federal or state funding is available. The case study also shows that the EIS Strategy promotes consideration of less expensive alternatives to centralized or regional systems.

3. Development Potential

Because of the similar natural environments and the tourist-oriented economies in the study area, development trends over the next 20 years will be generally similar for each 201 study location. Differences, such as the size of a community or proximity to a major city, may affect some aspects of barrier island life, but they do not alter the basic development trends.

Barrier island growth patterns will continue in the same direction that has occured for the past 15 years. Single family homes will predominate; multi-family structures will capture an expanding percentage of the total units built; commercial accomodations will retain the same percentage of units (except in Dare Beaches and Carteret County) and auxilliary commercial establishments will be built to provide services for the new population.

Table IV.1 Summary of Case Study Costs.

Scenario	Present Worth- No Funding, Federal Discount Rate	Average Monthly Costs per Typical Household	
		Total Cost[1] ($/month/dwelling)	Local Cost[2] ($/month/dwelling)
1. No Federal Action	1,402,310	4.02	5.28[3]
2. 201	12,007,000	37.20	21.10[4]
3. EIS #1	2,632,910	7.54	6.90[4]
4. EIS #2	4,217,120	12.08	9.46[4]

[1] No funding available; based on federal discount rate of 7 3/8% and 20 year financing.

[2] Based on current interest rates for financing - 8 1/2% for municipal bonds and 15% for private financing--and 20 year financing.

[3] No grant eligible costs.

[4] For capital costs which are grant eligible, assume funding available.

Source: Gannett Fleming Corddry & Carpenter, Inc. 1981.

Patterns of development on barrier islands are largely dictated by the elongated shape of the islands and the desire of island residents and visitors to be close to the water, preferrably the ocean. These two factors have resulted in linear development along island margins. This pattern was recognized and reinforced in the 201 Plans as sewers were designed to service existing development. Future development will continue in this mode because this pattern maximizes the amenities of shorefront living desired by island residents.

While the pattern of development would remain essentially the same as that in the proposed 201 Plans, the density of development under the EIS Strategy would probably be less than if sewers were available. These lower densities would be necessary to accomodate the land area requirements mandated by the rules and regulations governing on-site soil absorption systems. Lots platted prior to July 1, 1977 may use on-site systems on parcels as small as 5000 square feet, which produces a density equivalent to approximately 8.7 units/acre. After that date, newly platted lots were required to be a minimum of 7500 square feet, which would accomodate approximately 5.8 units/acre. The North Carolina Soil Absorption System regulations which became effective July 1, 1982 contain no requirements about development densities even though they require that density be considered.

4. Implementability

The EIS identified cost as the major constraint to implementation. The barrier island communities are characterized by relatively modest tax bases and highly fluctuating seasonal populations. Thus, the higher cost alternatives will be the most difficult to implement. Chapter II discussed in detail this aspect of implementability and pointed out that the absence of federal funding could make some of the central and regional systems proposed in the draft 201 Plans unaffordable. The reduction of federal funding from the 75 percent level to the 55 percent level after October 1, 1984, might have the same effect on implementability.

The EIS Strategy allows the 201 planning process to evaluate all reasonable technologies for wastewater management on the barrier islands. The use of various on-site and small community systems was investigated by the EIS. It was found that numerous alternative systems using soil absorption disposal are feasible for use on the barrier islands.

Both the EIS and No Federal Action Strategies could lead to greater use of soil absorption systems, but the impacts would probably differ. If the EIS Strategy is properly implemented, reductions in septic tank and other on-site failures should result. Other studies have shown that a large percent of on-site failures are attributable to improper installation and maintenance of systems. The implementation of a management program by a local health department or by a public on-site wastewater management agency could cause a decrease in system failures.

The analysis of existing development in Chapter II shows that most construction has taken place on soils suitable for soil absorption systems. Large amounts of land containing such soils remain undeveloped in each 201 planning area. It has been shown that sufficient acreage is found in each planning area to accomodate the year 2000 201-projected population with the use of soil absorption systems.

B. Mitigative Measures

Measures are suggested below to mitigate the significant adverse impacts which have been previously identified. These measures are intended to supplement existing development controls such as zoning ordinances, subdivision regulations, the Coastal Area Management program and the National Flood Insurance program. Many of these measures would be the responsibility of the local management agency.

1. Surface Water

- Conduct additional sampling programs so as to adequately document the extent and sources of water quality pollution in shellfishing waters.
- Renovate any known failing soil absorption systems and establish mechanisms for early identification of incipient failures.
- Assure routine inspection and pumping of soil absorption systems on a community wide basis so as to reduce failures.
- Control runoff from developed and developing areas by greater use of on-site retention facilities and avoiding storm sewering and curbs and gutters.
- Control discharges from bilges and sanitary facilities of commercial and pleasure boats, particularly within estuarine and marine waters. More stringent enforcement of Coast Guard regulations is required.
- Minimize the use of impervious surfaces in new development.
- Preclude surfacing of septic tank effluent and overland flow by proper installation, operation and maintenance of soil absorption systems.
- Implement or enforce best management practices for all new construction.

2. Groundwater

- Implement a water conservation program to reduce hydraulic loading on soil absorption systems. Increase public education and modify local plumbing codes.
- Establish a monitoring network to assure detection of any contaminated groundwater or salt water intrusion in potable water supplies or surface water bodies.

3. Sensitive Natural Areas

- Encourage developers to refrain from unnecessary clearing of vegetation, especially in maritime forests, so as to preserve wildlife habitat and decrease urban runoff.
- Encourage buffer zones and greenbelts to preserve open space and reduce noise impacts on wildlife and humans.

C. Irreversible/Irretrievable Commitments

The 201 Strategy represents an irreversible commitment of resources in the construction of interceptors, treatment plants and disposal facilities. The extensive use of soil absorption systems under the EIS and No Federal Action Strategy does not represent an irreversible commitment, in that central or regional wastewater systems can be installed if such systems become cost-effective at a later date.

D. Energy Requirements

The regional systems proposed by the draft 201 Plans would require more energy in construction, operation and maintenance than would conventional or modified septic tank systems. Small community systems would require a moderate amount of energy depending upon treatment processes and the use of pumps in the collection and disposal alternatives.

CHAPTER V. EIS COORDINATION

A. Introduction

The purpose of this chapter is to document the interaction and communications between EPA and its consultants with affected publics in the study area. A wide variety of mechanisms have been employed: public scoping meetings, a Review Committee, informal small group meetings with officials, letters, telephone calls, newspaper/radio/TV articles and announcements, workshops, newsletters and various types of handouts. An effort has been made to solicit input from a wide spectrum of community interests, to keep each group informed of study progress and to resolve conflicting points of view.

B. Description of the EIS Public Participation Program

1. Overview

Public participation was an important and valuable part of the EIS process because it provided for active public involvement in developing and evaluating strategies for wastewater management alternatives. At the beginning of the North Carolina Barrier Island EIS, a public participation program was established to provide opportunities for interested groups, individuals, and government agencies to participate in the development of the EIS. The focal point of this program was the establishment of a Review Committee selected from the entire study area of coastal North Carolina and appropriate inland locations. This group served in an advisory capacity to EPA and its consultants. Specific functions and duties of the group included:

- Identifying local and regional planning and environmental objectives
- Identifying study area issues and conflicts regarding wastewater management and environmental conditions
- Reviewing all task report submissions
- Assisting in the development and evaluation of strategies for selecting appropriate wastewater management alternatives
- Reviewing Draft and Final Environmental Impact Statements.

The Review Committee met at regular intervals throughout the development of the EIS. In addition, EPA and its consultants met upon request with individual members of the Review Committee and with the groups they represented. In order to provide ample opportunity for each EIS Review Committee member to attend each meeting and any attendant workshops, the Committee meetings were held in three locations along the coast.

The public participation program included four public scoping meetings, three public workshops conducted at three locations, and four series of Review Committee meetings, held at various coastal locations. The Review committee was composed of 48 individuals from public agencies and private organizations. A broad range of community interests were included: state and local government agencies, developers, homeowners associations, trade associations and business groups, and social service and environmental interests. Table V.1 lists the members of the Review committee.

The public participation program detailed above used a series of techniques for informing the public about the progress of the EIS process. Methods included newsletters, public workshops and Review Committee meetings. Comments received generally supported the idea of involving as many people as possible in the discussion of EIS issues.

2. Meeting Descriptions

a. Scoping Meetings

During September 1980, a public scoping meeting was held at the Archdale Building in Raleigh to describe the procedures EPA would use in preparing the EIS. The meeting included presentations on the purpose and background of the EIS, the 201 Plans, the scope of the EIS and issues to be addressed, the EIS schedule and a description of the public participation program. Afterwards, citizens and officials made comments. After this meeting, it became apparent that additional Scoping Meetings were necessary in the study area to provide ample opportunity for local interests to voice their opinions.

Three scoping meetings were held on November 10, 12, 13, 1980 at coastal locations (Manteo, Atlantic Beach and Wilmington) which were convenient for all those potentially affected by the EIS. Active participation at all three meetings by a broad range of interests helped to define local and state concerns and pinpoint the areas of misunderstanding created by the decision to proceed with an EIS. Information from these initial Scoping Meetings was used to assure that the primary issues of concern were addressed by the EIS.

Six major issues were identified that encompassed state and local perspectives and incorporated EPA's 201 Plan review comments. The issues which have been identified and are addressed in the EIS are as follows:

Water Quality - What water quality problems exist, how can they be documented, and can they be resolved by the 201 Wastewater Facilities Program?

Alternative Wastewater Technologies - Which wastewater management systems are appropriate for barrier island locations, considering soil properties, population served, costs, and administrative requirements?

Financial Impact on Local Governments - How can local governments determine the fiscal costs and managerial requirements associated with administering appropriate wastewater management systems?

Nonpoint Source Pollution - Will future development patterns result in an increased potential for nonpoint source pollution of surface waters?

Groundwater - What impacts will the various wastewater treatment alternatives have on the barrier islands' surficial aquifer?

Sensitive Natural Areas - How will the unique sensitive natural areas and storm hazard zones indigenous to barrier islands be affected by the provision of wastewater management?

Table V.1 EIS Review Committee Members.

1* Reginald R. Sutton - N.C. Department of Natural Resources & Community Dev.

1 Grover W. Cook - N. C. Department of Human Resources

3 Peggy Stamey - South Atlantic Fishery Management Council

3 Frederick W. Annand - N. C. Nature Conservancy

3 Dr. Orrin Pilkey, Jr. - Duke University

3 John Runkle - Conservation Council of N.C.

4 David Stick - Citizen

3 Dr. Vincent J. Bellis - East Carolina University

2 Stephen S. Sawin - Anchorage Realty

1 Milan J. Muzinich - N. C. Department of Natural Resources & Community Dev.

3 Larry Bray - Outer Banks Audubon Society

1 Jerry W. Hardesty - Coastal Resources Commission

3 Dr. Philip J. Adler - Sierra Club

1 Joseph J. Stokes - Health Director, Dare Co. Health Dept.

1 Anthony W. Barrett - Town Manager, Nags Head

1 W. A. Harris - Cape Hatteras National Seashore

2 C. Howard Cliborne, Jr. - Dare County Board of Realtors

3 James Harris - Harris Seafood Co.

2 Bob DeGabrielle - Realty World

2 Charles L. Smith - Old Nags Head Cove Property Owners Association

4 Rhett B. White - N. C. Marine Resources Center/Roanoke Island

3 Cathy Galucci - Sierra Club, Joseph LeConte Chapter

3 Woodrow Price - Wildlife Resources Commission

1 Jim Rickards - Carteret County Manager

1 Doug Fleming - Carteret County Commissioner

1 Preston P. Pate, Jr. - N. C. Office of Coastal Management

Table V.1 Continued

2 Roy A. Stevens - Carteret Co. Economic Development Council, Inc.

3 Fentress H. Munden - Marine Biologist - Shellfish Coordinator

4 Spencer Rogers, Jr. - Engineer, UNC Sea Grant

4 Rosetta Short - Coastal Resources Adv. Council

4 Dr. Paul Hosier - Department of Biology, UNC, Wilmington

1 Bill Faver - Holden Beach Town Administrator

1 Bob Jamison - N. C. Department of Natural Resources & Community Dev.

1 Robert W. Sawyer - Mayor of Wrightsville Beach

1 Karen Gottovi - New Hanover County Commissioner

1 Jerry D. Lewis - Environmental Management Commission

1 Francis Kanoy - Mayor of Sunset Beach

1 Clifford Howard - Mayor of Surf City

1 Odel Williamson - Ocean Isle Beach Town Council

1 John Harvey - Brunswick County Director of Planning

4 Jack Goldstein - President, Travel Council of N.C.

1 Kenneth Windley - County Planning Director

2 Judy Holden - Holden Beach Property Owners Association

4 James E. Sykes - Citizen

2 Robert W. Andrews - Southern Shores Planning Board

1 William L. Flournoy, Jr. - Office of Regulatory Relations,
N. C. Department of Natural Resources and Community Development

4 Trenton Davis - Department of Environmental Health, East Carolina University

4 Georgia H. Hammond - Citizen

*1 - government
2 - development
3 - conservation
4 - citizens at large

b. First Meeting Series

The initial EIS Review Committee meeting series (February 3, 4, 5, 1981) was held primarily to discuss the Plan of Study. An additional discussion topic focused on the extent and adequacy of the proposed Public Participation Program. Comments and questions from reviewers indicated agreement with the Plan of Study upon the realization that the EIS would be addressing procedural issues rather than selecting an appropriate wastewater treatment facility.

c. Second Meeting Series

The second series of meetings of the EIS Review Committee (May 19, 20, 21, 1981) combined a public technical workshop with the formal Committee meeting. The intent was to disseminate the findings of the Environmental Inventory Report and provide an opportunity to discuss the implications of the comprehensive information. In addition, the workshop provided a progress report on the EIS for all those who were not members of the Review Committee. Discussions at the formal committee meeting focused on sensitive natural areas, on-site wastewater treatment technologies and the thoroughness of the Environmental Inventory Report. The Committee's comments supported further investigation of on-site systems based on the information provided in the report and during the workshop presentations. Further discussion indicated the opinion among participants that current environmental protection under the Coastal Management Program is adequate to protect vital resources on the barrier islands.

The workshops consisted of three presentations addressing critical barrier island issues: the wastewater treatment facilities proposed for each of the five 201 planning areas, criteria for siting on-site wastewater treatment systems and a description of the sensitive natural areas found on barrier islands. Discussions among all workshop participants followed each presentation. The topic of on-site systems elicited many comments because these systems were commonly thought to be inadequate for barrier island use. The EIS consultants, however, pointed out that new siting and installation techniques have shown these systems are appropriate for use along the North Carolina coast.

d. Third Meeting Series

The third meeting series (October 27, 28, 29, 1981) combined three technical workshops with a central Committee meeting in New Bern. The central meeting of the Committee was designed to bring all the Review Committee members together to assure that regional as well as local wastewater concerns were being properly addressed by the EIS. Apparently, the travel distances and inconvenience were too great for most members as only seven of the 48 members attended the meeting. Workshops, however, were held in Bolivia, New Bern and Manteo and were attended by many Review Committee members and public officials.

The Committee meeting was held to discuss and review the Alternatives Development Report. Since most of the Committee members had attended one of the local afternoon workshops, brief presentations were made by the EIS consultants addressing the procedures identified and described in the report. Specific topics included documentation of water quality problems, population projections, technical wastewater treatment systems available for barrier island use, and financial and institutional considerations that should be addressed during 201 Plan preparation. In general, the Committee members agreed that the procedures presented would lead to reasoned wastewater management decisions based on a review of local social, institutional, environmental and financial data.

The three local workshops were conducted to disseminate information generated by the EIS that would affect local wastewater facilities planning decisions. The EIS consultants presented three topics for discussion: problem identification techniques, technical considerations for selecting wastewater treatment facilities, and financial and institutional considerations for wastewater planning. Approximately 45 persons attended the workshops including Review Committee members, the general public, 201 Plan consultants and public officials. Most participants agreed that the procedures presented addressed critical issues in a logical manner which included the unique aspects of coastal communities dominated by the effects of seasonal tourism.

Fourth Meeting Series

The fourth series of Review Committee meetings and workshops was held January 12, 13 and 14, 1982 in Manteo, Pine Knoll Shores and Bolivia. A workshop on financial planning for local wastewater management was presented each afternoon prior to the evening meetings. Special mailings to local elected officials and financial administrators helped to alert appropriate workshop attendees.

The EIS Review Committee meeting began with brief presentations by the EIS consultants describing the purpose of the Alternatives Evaluation Report and the findings of the hypothetical case study. Attending Review Committee members and those contacted after the meetings agreed with the evaluation and endorsed the EIS Strategy as the most effective in addressing wastewater treatment issues on the barrier islands.

The objective of the associated afternoon workshops was to provide a series of worksheets and accompanying procedures that would allow each local community to assess its fiscal health in light of current economic conditions and wastewater management costs. The worksheets include procedures for identifying available fiscal sources, evaluating current expenses, determining the degree of financial risk, evaluating financial capabilities and summarizing financial and institutional information.

CHAPTER VI. LIST OF PREPARERS

U. S. Environmental Protection Agency

Robert B. Howard	Chief, NEPA Compliance Section
W. Bowman Crum	EIS Project Officer
Peter T. McGarry	Chief, NC/KY Facilities Planning Section

Consultants

Claude Terry & Associates, Inc.

Claude E. Terry	Project Executive
Louise B. Franklin	Project Manager (after 8/81), Environmental Planner
Gordon C. Carruth	Project Manager (prior to 8/81), Environmental Planner
Robert J. Hunter	Environmental Scientist
Michael Brewer	Environmental Scientist
Craig H. Wolfgang	Environmental Scientist
James Hodges	Environmental Scientist
Thomas C. Mather	Environmental Scientist
R. Gregory Bourne	Environmental Engineer
R. B. Coulter	Environmental Engineer

Gannett Fleming Corddry and Carpenter, Inc.

Thomas M. Ratchford	Senior Project Manager
Albert T. Bain	Project Manager (after 3/81)
Jeffrey Wendle	Project Manager (prior to 3/81)
P. Andre DeGeorges	Environmental Scientist
Sarah Frailey	Project Engineer
John W. Jacobs	Environmental Scientist

Briscoe, Maphis, Murray & Lamont, Inc.

James Murray	Institutional Analyst
Suzanne Cohen Zoda	Institutional Analyst

ERDAS, Inc.

Lawrie E. Jordan III	Project Manager
Jefferson K. Dooley	Data Base Management

CHAPTER VII. COORDINATION LIST

Federal Government

Cooperating Agencies:

U. S. Army Corps of Engineers
    South Atlantic Division, Atlanta, Georgia
    Wilmington District, Wilmington, North Carolina

Federal Emergency Management Agency
    Insurance and Mitigation Division, Atlanta, Georgia

Other

U. S. Soil Conservation Service
    State Conservationist, Raleigh, North Carolina

National Park Service
    Cape Hatteras National Seashore
    Cape Lookout National Seashore

U. S. Fish and Wildlife Service
    Pea Island National Wildlife Refuge

State Government

N. C. Department of Natural Resources and Community Development
    Division of Environmental Management
    Office of Coastal Management
    Resource Planning and Assessment Office
    Washington Regional Office
    Wilmington Regional Office

N. C. Division of Health Services
    Environmental Health Section
    Water Supply Branch

Regional and Local

Brunswick County Health Department

Brunswick County Planning Department

Onslow County Planning Department

Carteret County Planning Department

Dare County Health Department

Municipal Governments:
- Sunset Beach
- Holden Beach
- Yaupon Beach
- Ocean Isle Beach
- Long Beach
- Southport

CHAPTER VII. COORDINATION LIST (continued)

Surf City
Atlantic Beach
Nags Head
Topsail Beach
Pine Knoll Shores
Manteo
Kill Devil Hills

North Carolina Agricultural Extension Service

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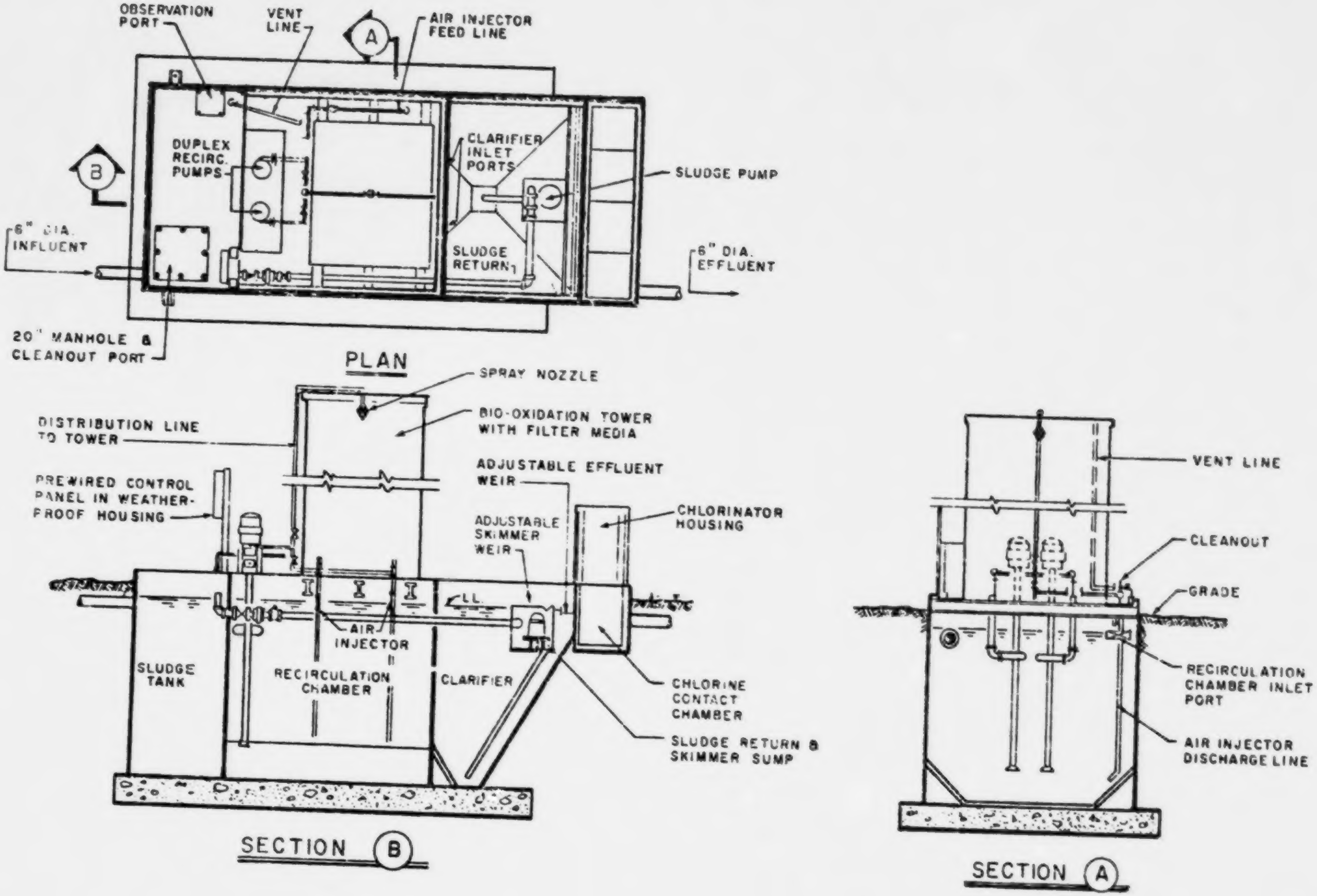
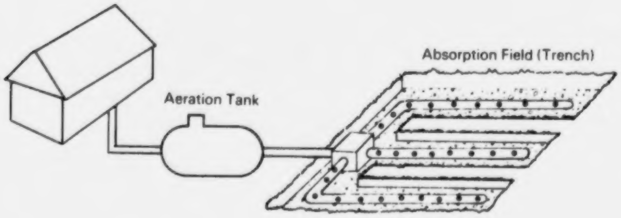
APPENDIX A

DETAILS OF WASTEWATER MANAGEMENT OPTIONS


OBSERVATION PORT
VENT LINE
A
AIR INJECTOR FEED LINE
B
DUPLEX RECIRC. PUMPS
CLARIFIER INLET PORTS
SLUDGE PUMP
6" DIA. INFLUENT
SLUDGE RETURN
6" DIA. EFFLUENT
20" MANHOLE & CLEANOUT PORT
PLAN
SPRAY NOZZLE
DISTRIBUTION LINE TO TOWER
BIO-OXIDATION TOWER WITH FILTER MEDIA
ADJUSTABLE EFFLUENT WEIR
PREWIRED CONTROL PANEL IN WEATHER-PROOF HOUSING
ADJUSTABLE SKIMMER WEIR
CHLORINATOR HOUSING
L.L.
AIR INJECTOR
SLUDGE TANK
RECIRCULATION CHAMBER
CLARIFIER
CHLORINE CONTACT CHAMBER
SLUDGE RETURN & SKIMMER SUMP
SECTION B
VENT LINE
CLEANOUT
GRADE
RECIRCULATION CHAMBER INLET PORT
AIR INJECTOR DISCHARGE LINE
SECTION A

Extended filtration package plant. USEPA "Process Design Manual—Wastewater Treatment Facilities for Sewered Small Communities" October 1977.

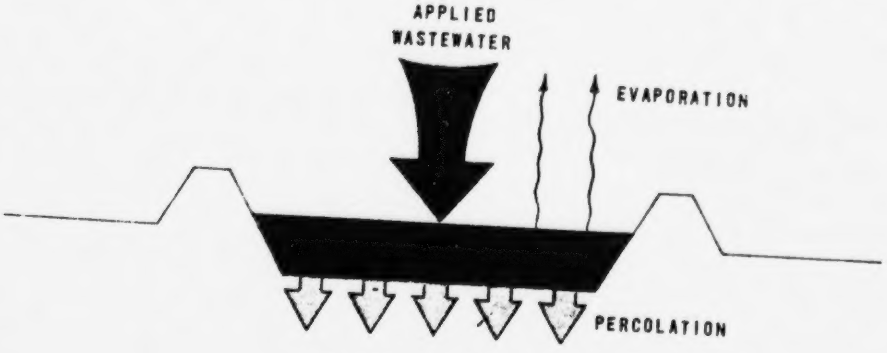
Air and wastewater are mixed in tank. Oxygen-using (aerobic) bacteria grow, digest sewage, liquefy most solids. Liquid discharges to absorption field where treatment continues. Can use same treatment & disposal methods as septic tank. Maintenance essential. Uses energy.



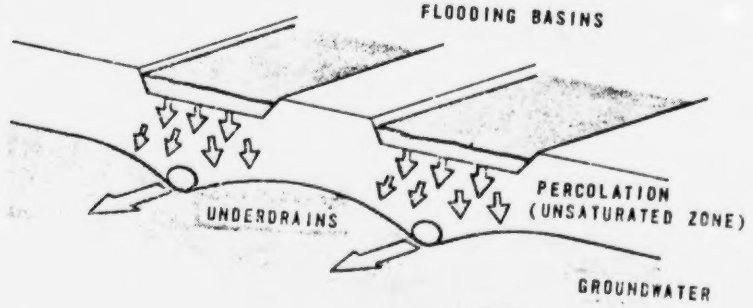
Aerobic system and soil absorption field

Source: USEPA Small Wastewater Systems "Alternative Systems for Small Communities and Rural Areas"

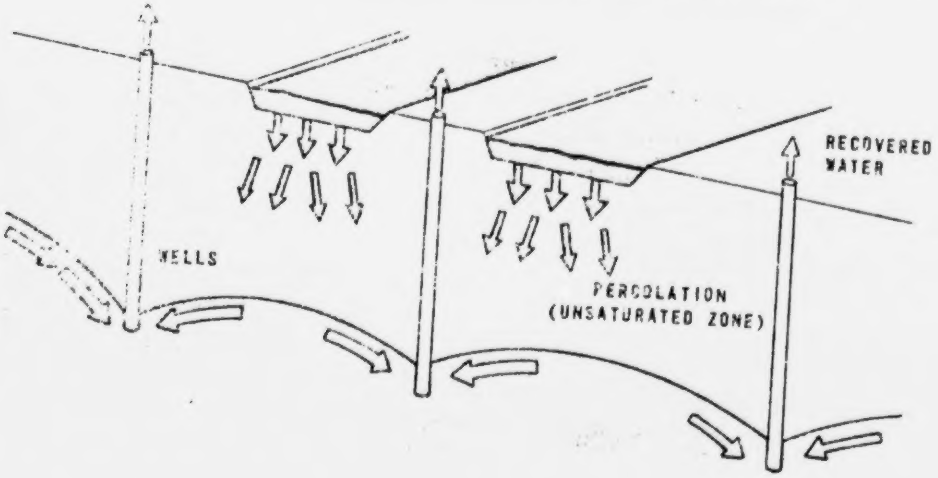
RAPID INFILTRATION


APPLIED WASTEWATER
EVAPORATION
PERCOLATION

(a) HYDRAULIC PATHWAY


FLOODING BASINS
UNDERDRAINS
PERCOLATION (UNSATURATED ZONE)
GROUNDWATER

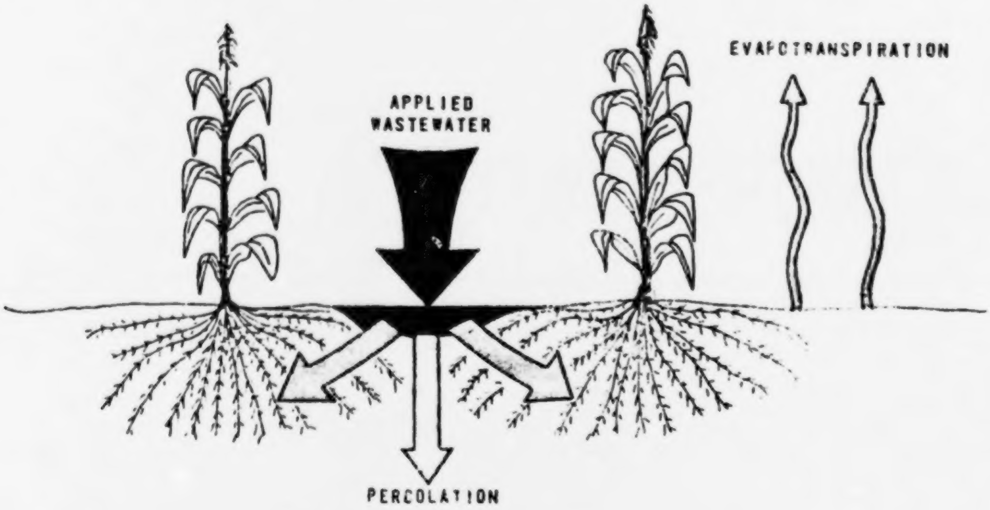
(b) RECOVERY OF RENOVATED WATER BY UNDERDRAINS


RECOVERED WATER
WELLS
PERCOLATION (UNSATURATED ZONE)

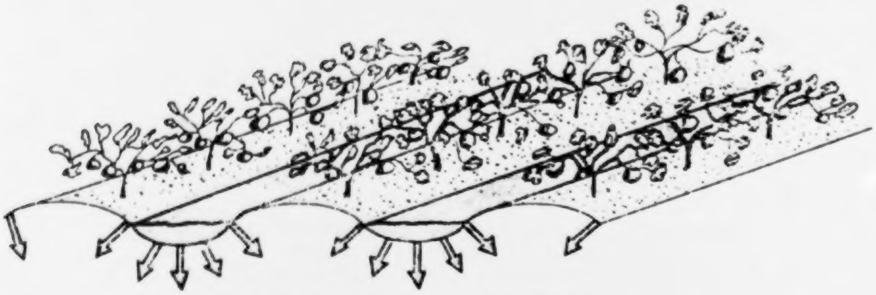
(c) RECOVERY OF RENOVATED WATER BY WELLS

Source: USEPA Technology Transfer "Process Design Manual for Land Treatment of Municipal Wastewater" October 1977.

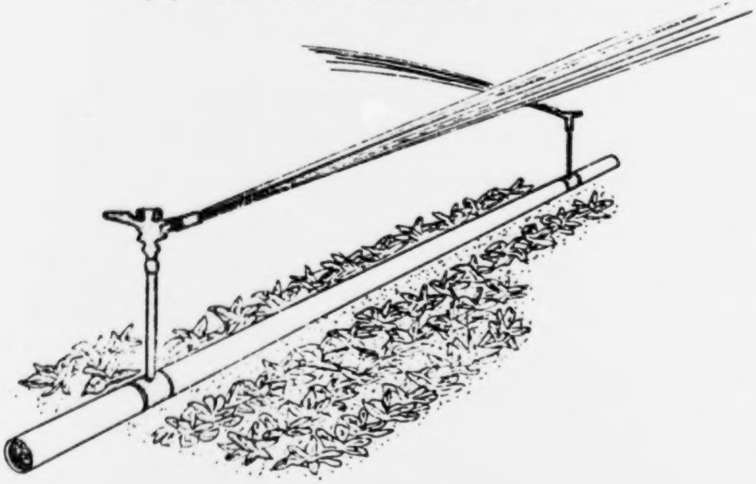
SLOW RATE LAND TREATMENT


APPLIED WASTEWATER
EVAPOTRANSPIRATION
PERCOLATION

(a) HYDRAULIC PATHWAY



(b) SURFACE DISTRIBUTION

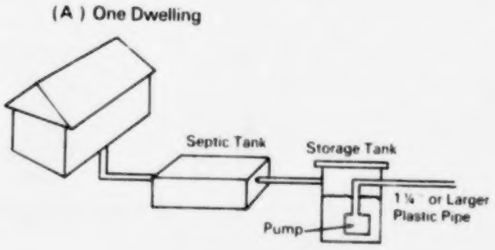


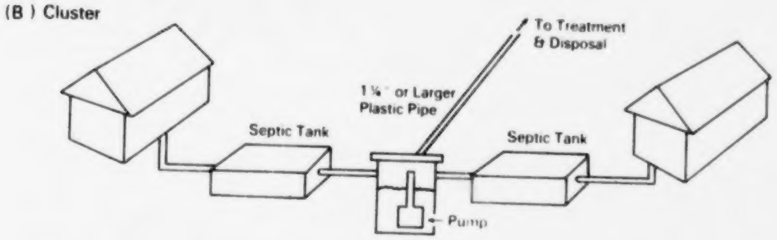
(c) SPRINKLER DISTRIBUTION

Source: USEPA Technology Transfer "Process Design Manual for Land Treatment of Municipal Wastewater"
October 1977

(A) One dwelling. Pump forces liquid from septic tank through plastic pipe to further treatment & disposal. Sludge is pumped from septic tank periodically.

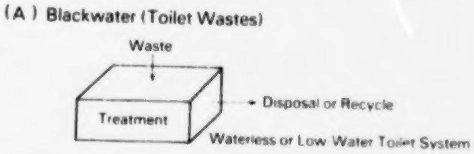
(B) Cluster system. Liquid from several septic tanks flows to one pumping tank. Pump forces liquid through plastic pipe to treatment & disposal.

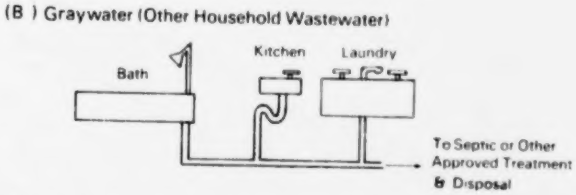

(A) One Dwelling
Septic Tank
Storage Tank
1 ¼" or Larger Plastic Pipe
Pump


(B) Cluster
To Treatment & Disposal
1 ¼" or Larger Plastic Pipe
Septic Tank
Septic Tank
Pump

Pressure Sewers, STEP (Septic tank effluent pump)

Many systems. In this one: (A) toilet wastes (blackwater) are handled by waterless or low-water toilet system
(B) Other household wastewater from kitchen, bath, laundry (graywater) needs separate treatment & disposal.

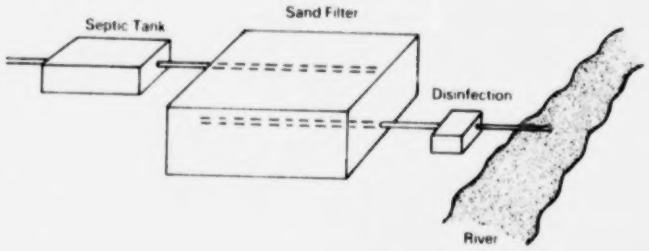

(A) Blackwater (Toilet Wastes)
Waste
Treatment
Disposal or Recycle
Waterless or Low Water Toilet System


(B) Graywater (Other Household Wastewater)
Bath
Kitchen
Laundry
To Septic or Other Approved Treatment & Disposal

Dual Systems: Blackwater and Graywater

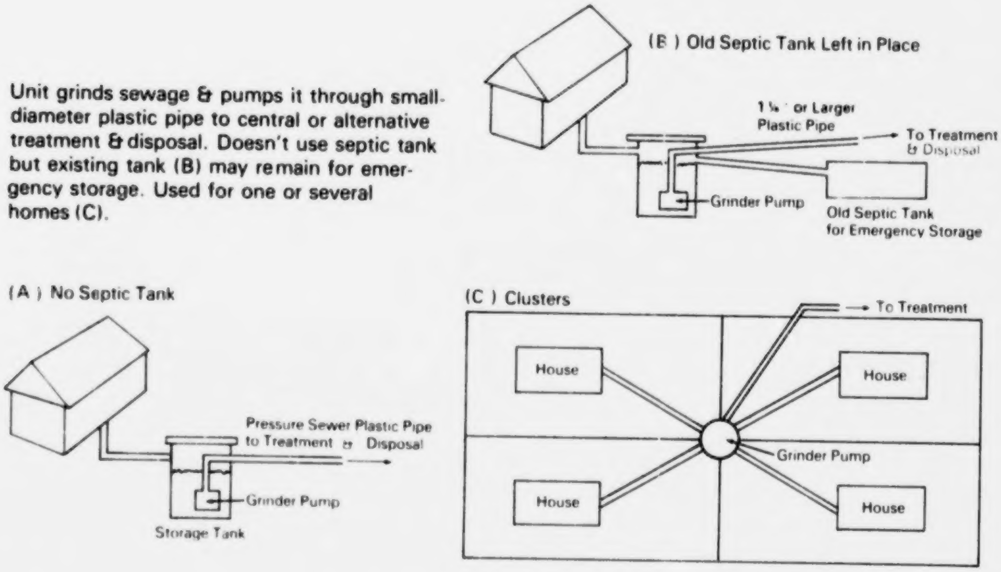
Source: USEPA Small Wastewater Systems "Alternative Systems for Small Communities and Rural Areas"

Filter is ground-level or buried sand pit. Liquid enters perforated pipe at top & filters through sand & gravel to bottom pipe. Bottom pipe conducts liquid to disinfection tank. Liquid discharges to stream or ditch. Variations are intermittent sand filter & recirculating sand filter. Used where soil absorption field not possible.


Septic Tank
Sand Filter
Disinfection
River

Septic tank, sand filter,
disinfection and discharge

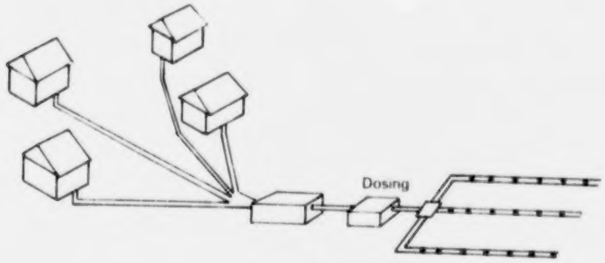
Unit grinds sewage & pumps it through small-diameter plastic pipe to central or alternative treatment & disposal. Doesn't use septic tank but existing tank (B) may remain for emergency storage. Used for one or several homes (C).


(B) Old Septic Tank Left in Place
1 ¼" or Larger
Plastic Pipe
To Treatment
& Disposal
Grinder Pump
Old Septic Tank
for Emergency Storage
(A) No Septic Tank
Pressure Sewer Plastic Pipe
to Treatment & Disposal
Grinder Pump
Storage Tank
(C) Clusters
To Treatment
House
House
Grinder Pump
House
House

Pressure sewers, GP
(Grinder Pump)

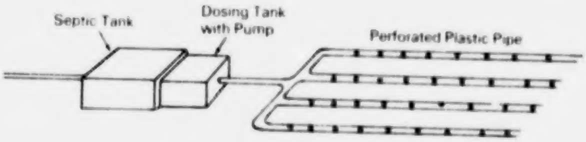
Source: USEPA Small Wastewater Systems "Alternative Systems for Small Communities and Rural Areas"

Several houses are served by common treatment and disposal system. Houses could also have onsite septic or aerobic tanks with liquid conducted to common absorption field. Clusters of houses can also use other alternative systems, such as mounds, pressure and vacuum sewers and sewage treatment lagoons.



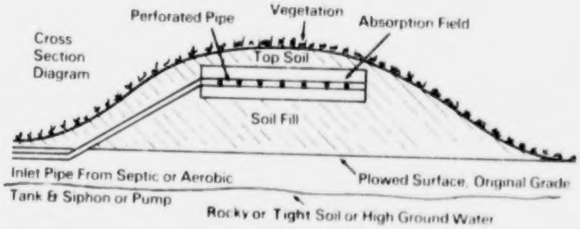
Cluster system
(two or more users on one alternative system)

Network of small-diameter perforated plastic pipes are buried 6"-18" in 4"-6"-wide trenches. Pump forces liquid through pipes in controlled doses so liquid discharges evenly. Site and soil determine pipe layout and pipe-hole size and number. Absorption field is same size as conventional field. Rocky or tight soil or high water table.


Septic Tank
Dosing Tank with Pump
Perforated Plastic Pipe

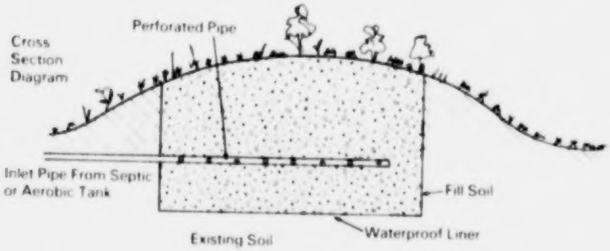
Low-pressure subsurface pipe distribution

Liquid is pumped from storage tank to perforated plastic pipe in sand mound that covers plowed ground. Liquid flows through rocks or gravel, sand, and natural soil. Mound vegetation helps evaporate liquid. Rocky or tight soil or high water table.


Cross Section Diagram
Perforated Pipe
Vegetation
Absorption Field
Top Soil
Soil Fill
Inlet Pipe From Septic or Aerobic Tank & Siphon or Pump
Plowed Surface, Original Grade
Rocky or Tight Soil or High Ground Water

Mound system
(used with septic or aerobic tank)

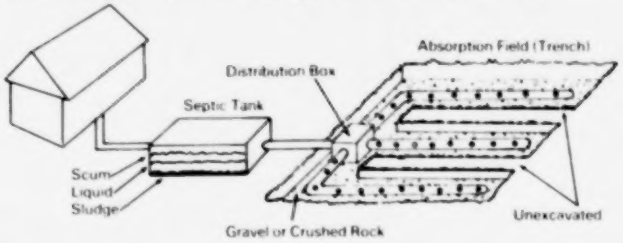
Sand bed is lined with plastic or other waterproof material. Bed could be mound or level. Liquid evaporates because liner prevents it from filtering through natural soil. Plants speed evaporation by drawing moisture from soil and breathing it into the air. Used where conventional absorption field not possible.


Cross Section Diagram
Perforated Pipe
Inlet Pipe From Septic or Aerobic Tank
Fill Soil
Existing Soil
Waterproof Liner

Evapotranspiration bed
(used with septic or aerobic tank)

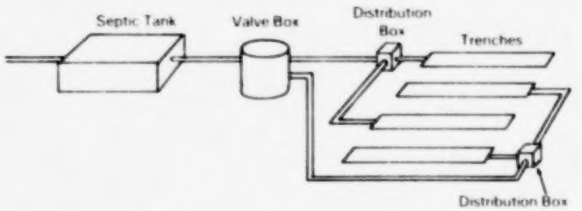
Source: USEPA Small Wastewater Systems "Alternative Systems for Small Communities and Rural Areas"

Sewage bacteria break up some solids in tank. Heavy solids sink to bottom as sludge. Grease & light particles float to top as scum. Liquid flows from tank through closed pipe and distribution box to perforated pipes in trenches; flows through surrounding crushed rocks or gravel and soil to ground water (underground water). Bacteria & oxygen in soil help purify liquid. Tank sludge & scum are pumped out periodically. Most common onsite system. Level ground or moderate slope.


Absorption Field (Trench)
Distribution Box
Septic Tank
Scum
Liquid
Sludge
Gravel or Crushed Rock
Unexcavated

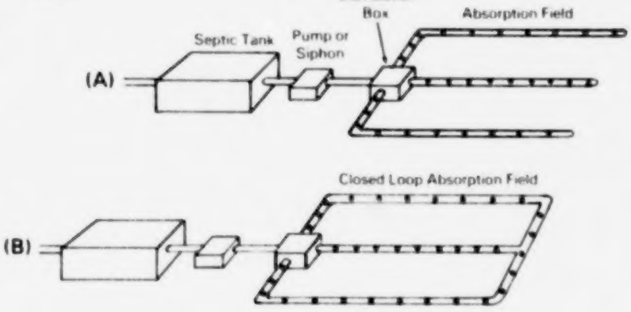
Septic tank and soil absorption field (trench)

One field rests while other is in use. Allows field to renew itself. Extends life of field. Provides standby if one field fails. Valve directs sewage liquid to proper field. Fields usually switched every 6-12 months.


Septic Tank
Valve Box
Distribution Box
Trenches
Distribution Box

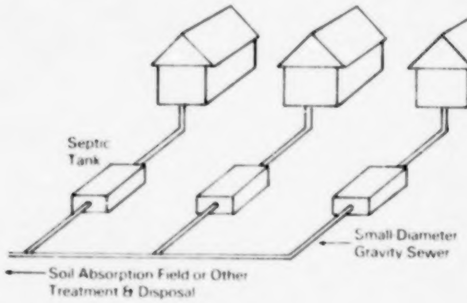
Septic tank with alternating absorption fields

(A) Pump or siphon forces liquid to perforated pipes in controlled doses so all pipes discharge liquid almost at same time (dosing). Spreads liquid more evenly & gives field chance to dry out between dosings. (B) Variation of Sketch 1 absorption field. Can be used for dosing & where ground is level or nearly level.


Distribution Box
Absorption Field
Septic Tank
Pump or Siphon
(A)
Closed Loop Absorption Field
(B)

Septic system refinements:
(A) Dosing (B) Closed loop

4"- 6" pipe is sloped so liquid from septic or aerobic tank flows through pipe to treatment & disposal. Treatment & disposal system can be conventional or alternative. Small pipe costs less than conventional 8" pipe.


Septic Tank
Small Diameter Gravity Sewer
Soil Absorption Field or Other Treatment & Disposal

Small-diameter gravity sewers
(collection system)

Source: USEPA Small Wastewater Systems "Alternative Systems for Small Communities and Rural Areas"

APPENDIX B

WASTEWATER MANAGEMENT SYSTEM SELECTION CRITERIA

Source: USEPA. 1980. Design manual: on-site wastewater treatment and disposal systems. p. 22, Table 3-2.

N. C. Dept. of Human Resources, Div. of Health Services, Environmental Health Sec. July 1, 1982. Laws and rules for ground absorption sewage treatment and disposal systems. Section 1900, North Carolina Administrative Code; Title 10, Health Services, Environmental Health; Subchapter 10A, Sanitation. W/October 30, 1982 and January 1, 1983 Amendments.

USEPA. October 1977. Alternatives for small wastewater treatment systems--on-site disposal/septage treatment and disposal.

Table 1. Criteria for Determining the Suitability of Sites for on-Lot Subsurface Soil Absorption Systems on Barrier Islands

Site Parameter	Suitable	Provisionally Suitable Only with Modifications to System	Unsuitable
I. Soil Character			
A. Texture - refers to the relative proportion of the various sizes of solid particles in the soil that are smaller than 2 mm in diameter.	Sandy and coarse loamy soils. Clayey soils with blocky soil structure.	Fine loamy soils. Clayey soils with blocky soil structure.	Deep clayey soils. Organic soils.
B. Structure - refers to the aggregation of soil particles into clusters of particles, called peds, that are separated by surfaces of weakness which open planar pores between the peds.	Sandy and coarse loamy soil structures.	Blocky soil structure in fine loamy and clayey soils.	Platey soil structure in clayey and fine loamy soils. Massive (absence of structure).
C. Depth	Greater than 48 inches.	Less than 48 inches and greater than 36 inches. Less than 36 inches where modifications of conventional system can be made.	Less than 36 inches for conventional systems. Less than 12 inches for certain modified systems.
D. Restrictive horizon - bedrock, iron pans (plinthite) and cemented iron-aluminum - organic hard pan (such as organic mucks and peats).	Greater than 48 inches below ground surface (ideal situation is when it is greater than 72 inches).	Between 36 and 48 inches. Less than 48 inches maybe suitable for use by modified conventional, pressure, or mound systemss.	Less than 36 inches below the ground surface. Less than 12 inches for certain modified system.
E. Drainage - soils with seasonally high water table; indicated by color and color patterns in the soil.	Subsurface Soil colors of reds, yellows, and browns.	Grayish soils with suitable texture and structure and modified to keep groundwater at least 12 inches below the trench bottom of subsurface disposal system.	Grayish soil profiles of chroma 2 or less within 12 inches of the ground surface.
F. Filtering Capacity - treatment ability		Soils underlain by loose sand and gravel or fractured bedrock at a depth less than 4 feet below the distribution lines.	
II. Topography			
A. Slope of hills and pattern of terrain.	uniform slopes under 15 percent	Uniform slopes between 15 percent and 30 percent if soils are deep (greater than 36 inches). Uniform slopes greater than 30 percent if a thorough study of the soil shows the following:	Slopes greater than 30 percent (rarely present on barrier islands). Complex slope patterns and slopes dissected by gullies and ravines.

Table 1. Continued

Site Parameter	Suitable	Provisionally Suitable Only with Modifications to System	Unsuitable
		(1) Slope can be terraced or graded to maintain a minimum 10 foot horizontal distance from bottom of subsurface disposal system lines and the ground surface. (2) Soils classified as suitable or provisionally suitable. (3) Surface water runoff is diverted. (4) Groundwater is intercepted and diverted, if necessary. (5) Sufficient ground area is available for modifications.	
III. Groundwater			
A. Seasonal high water table level.	Greater than 48 inches below ground surface.	Less than 48 inches below ground surface but greater than 36 inches for conventional systems. Between 36 and 12 inches below ground surface for modified systems.	Less than 36 inches below ground surface for conventional systems. In the range 0 to 1 ft. for modified systems.
IV. Flood Susceptibility	None (protected)	Rarely occurring	10-year or less frequency
V. Land Area			
A. Space availability - required space is calculated based on the square footage required for the previously determined application rate.	Area with less than 3 houses per acre. Area to contain at least 1,000 sf of open "green area" per house served or 2,500 sf/1,000 gal. of wastewater/day.	Sites classified as provisionally suitable concerning soils and topography are suitable if there is sufficient available space to accomodate a replacement subsurface disposal field.	Available space insufficient to permit installation and proper functioning of conventional system (based on application rate). Adequate repair space insufficient (some individual lots exempt).
B. Minimum horizontal distance requirements	Private water supply - 100 ft. Community Water Supply - 100 ft. Streams classified as A-II - 50 ft. Water classified as SA - 100 ft.		

Table 1. Continued

Site Parameter	Suitable	Provisionally Suitable Only with Modifications to System	Unsuitable
	Any other lake or impoundment - 50 ft from normal high water line. Any other stream, canal, marsh, or coastal waters - 50 ft. Any Class I or II impounded reservoir used as a source of drinking water - 100 ft. (normal high water line) Any building foundation - 5 ft. Any basement - 15 ft. Any property line - 10 ft. Top of slope of embankments or cuts of 2 ft. or more vertical height - 15 ft. Any water line - 10 ft. Any swimming pool - 5 ft. Any other nitrification field - 20 ft. Interceptor drains - 10 ft. upslope and 25 ft. downslope. Groundwater lowering and surface drainage ditches - 25 ft.		
VI. Loading Rate	Flows not exceeding 1.2 gallons per square foot of trench bottom.	Flows greater than 1.2 gallons per square foot of trench if data from soil study indicate that the high rate is justified.	

Table 2. Individual On-Site Treatment/Disposal Systems

System	Advantages	Disadvantages	Modifications	Constraints
Septic Tank/Soil Absorption Field Wastewater is discharged to a water-tight container in which it is retained to allow solids to settle and partially decompose by anaerobic bacterial action. Clarified effluent is conveyed by gravity in a closed pipe to a distribution box from which it flows by gravity or dosing to perforated pipes in the absorption field. Effluent flows from the pipes through the surrounding crushed rock or gravel to the soil to be absorbed by unsaturated particles. Soil absorption field may consist of a bed or trenches.	(1) Relatively low construction costs. (2) Minimum operation and maintenance requirements. (3) Generally no mechanical moving parts or power requirements. (4) Bacteria and oxygen in the soil help purify the tank effluent.	(1) Poor quality clarified effluent from tank. (2) Septic tank must be pumped every two to three years to remove accumulated sludge and scum. (3) Trenches subject to solids clogging. (4) Large land area requirements based on effluent application rate to absorption system. Best suited for sites with three or less houses per acre.	(1) Two compartment septic tank with baffle wall or partition 2/3 to 3/4 the distance from the inlet. This enhances the tank's clarification capabilities (2) Alternating absorption fields to allow field to renew itself and extend its life. Also provides a standby if one field fails. Fields usually switched every 6 to 12 months (3) V-ditch (V-shaped trenches) to maximize the ratio of sidewalls to bottom area and minimize depth requirements. (4) Low pressure pipe system for uniform distribution of effluent in the field. (5) Senal distribution for sloping fields (contoured absorption field with drop boxes).	(1) Slopes should not be in excess of 5 percent and depressions should be avoided. (2) Minimum horizontal separation distance requirements: Water supply wells, 100 feet; Surface waters, 50-100 feet; Escarpments, manmade cuts, 15 feet; Boundary of property 10 feet; Building foundations, 15 feet. (3) Seasonal high groundwater level and restrictive horizons must be at least 3 feet below the ground surface.
Septic Tank/Mound System Clarified effluent from the septic tank is pumped or siphoned to a mound constructed on the natural soil surface with imported moderate to fine featured sands or loams at a depth of 1 to 2 feet. On top of the filter material the pipe distribution network is constructed within a gravel bed. A protective	(1) Provides a zone of treatment above the natural soil and the underlying restrictive horizon. Purification is achieved as effluent moves through the mound and is lost by evapotranspiration and soil percolation. (2) Can be used where soil conditions are not suitable for conventional absorption	(1) Poor quality clarified effluent from tank (2) Septic tank must be pumped every two to three years to remove accumulated sludge and scum. (3) Relatively high construction costs and maintenance costs. (4) Usually requires pumping. (5) More difficult to construct than conventional	(1) Septic renovation levy is the name applied to system in which the effluent is pumped into the top of the mound in controlled doses through small diameter perforated pipes. (2) Two compartment septic tank.	(1) Slopes should not be in excess of 12 percent and depressions should be avoided. (2) Minimum horizontal separation distance requirements are the same as those for conventional absorption fields except that distance from building foundations should be 30 feet when

Table 2. Continued

System	Advantages	Disadvantages	Modifications	Constraints
Septic Tank/Mound System (continued) covering of fine textured soil is also placed over the mound and seeded for runoff control.	fields such as slow or rapid permeable soils, shallow permeable soils over creviced or porous bedrock, and permeable soils with high water table. (3) Allows development of restricted lot sizes.	absorption field (6) Visual impact of mound causes aesthetic and possible landscape problems.		located unslope from a building in slowly permeable soils. (3) Seasonal high groundwater level and restrictive horizon must be at least 12 to 36 inches below original soil surface.
Septic Tank/Artificially Drained System Clarified effluent from the septic tank is conveyed to a soil absorption field for disposal. The water table below the field is artificially lowered to permit effective disposal. Drainage techniques applicable are curtain drains for perched water tables and lateral groundwater flow problems and underdrains for perched water tables and free water tables.	(1) Can be used where high water tables restrict use of conventional soil absorption system	(1) Poor quality clarified effluent from tank (2) Septic tank must be pumped every two to three years to remove accumulated sludge and scum. (3) Relatively high construction costs (4) Drainage units require infrequent cleaning to maintain their effectiveness. (5) When utilizing underdrains, sometimes a network of drains is required. (6) Few on-site installations existing to provide performance records of the drainage techniques. (7) May require a pump discharge of groundwater.	(1) Two compartment septic tank.	(1) Soils to be coarse textured because fine textured soils of slow permeability are impractical for subsurface drainage. (2) Soils that are saturated for prolonged periods, particularly on level sites, are not practical to drain. (3) A separation distance of 10 feet is recommended between the curtain drain and the absorption field downslope. (4) Minimum horizontal separation distance requirements of the absorption field same as these stated for the conventional field previously mentioned.
Septic Tank/Evaporation Lagoons Clarified effluent from the septic tank is conveyed to an open holding facility which	(1) Effectively treats wastewater in areas which have soil conditions not conducive to	(1) Poor quality clarified effluent from tank. (2) Septic tank and lagoon must be pumped every	(1) Evaporation/Infiltration Lagoon omits the use of an impermeable liner so that soil	(1) Local health ordinances may restrict use due to potential health hazard.

Table 2. Continued

System	Advantages	Disadvantages	Modifications	Constraints
depends solely on climatic conditions to effect dissipation (evaporation) of wastewater. The lagoon is lined with an impermeable plastic liner to prevent soil absorption. Provisions may be required to add makeup water to maintain a minimum depth during dry hot seasons.	the utilization of conventional on-site disposal systems or systems using soil absorption. (2) Utilize meterologic and climatological factors for the operation of the lagoon.	two to three years to remove accumulated sludge and scum. (3) Lagoon has potential for odors and health hazards. (4) Large land area requirements and public access restrictions are necessary for the lagoon. (5) Lagoon may adversely affect surrounding property values. (6) Few on-site installations existing to provide performance records of the lagoon system.	permeability can also be incorporated in the disposal of the effluent. Soil should be of slow permeability.	(2) Annual evaporation rates should exceed the annual precipitation. (3) Land area requirements are a major factor.
Septic Tank Polishing/ Surface Discharge Clarified effluent from the septic tank is conveyed to additional treatment processes for polishing. These processes are normally either buried sand filters, intermittent sand filters, or recirculating sand filters that utilize underdrains when applicable. Disinfection units are also incorporated when necessary prior to discharge to surface waters.	(1) Can be used where subsurface disposal systems are not feasible. (2) Relatively small space requirements.	(1) Septic tank must be pumped every two to three years to remove accumulated sludge and scum. (2) Pumping is required for using intermittent and recirculating sand filters and possibly for the discharge outfall. (3) Construction and Operation/Maintenance costs are relatively high. (4) Centralized management, rather than homeowners, are normally required for successful operation (filter surfaces and disinfection equipment requires periodic maintenance). (5) Potential odor problem from filters. (6) Public access may need to be restricted due to potential health hazard.	(1) Disinfection methods available that have proven effective against bacterial and viral pathogens for on-site application include tablet chlorination, iodine crystals, and ultraviolet irradiation (dry feed chlorinators may require mechanical dosage control).	(1) Surface discharge must be permitted by the regulatory agency (state or federal permits). (2) A receiving surface water must be available (fresh or ocean waters). (3) Sampling and monitoring system is required.

Table 2. Continued

System	Advantages	Disadvantages	Modifications	Constraints
Septic Tank Polishing/ Surface Discharge (Cont)		(7) Chlorine disinfection can result in the production of toxic chlorinated organics in final effluent being discharged.		
Aerobic Treatment Units/ Non-Surface Disposal Wastewater is discharged into an aeration chamber where it is aerobically treated by either a suspended growth (activated sludge, using either a batch or flow-through, extended aeration operation) or by a fixed-growth (packed tower, rotating contractor, or submerged media systems) process. Aeration may be provided by natural convection, mechanical aeration, or forced air ventilation. The aeration chamber is followed by a clarification unit (can utilize a septic tank), along with recycling of treated wastewater back to the fixed-media. Treated effluent is discharged either to a soil absorption field, mound system, or a lagoon for final disposal	(1) Aerobic units, when properly operated and maintained, can result in a higher effluent quality than septic tanks and can reduce clogging in coarse (sandy) soils for soil absorption systems. (2) Cleaner effluent also allows for a reduction in soil absorption area requirements, generally a 1/3 reduction. (3) Aerobic treatment units are being produced by more manufacturers as self-contained package plant with various features incorporated into the design to reduce the need for frequent surveillance and thereby avoid some problems associated with operation and maintenance.	(1) Aerobic units are more prone to microbial upsets if not maintained properly. (2) Construction costs and operation/maintenance costs are relatively high. (3) Few on-site installations for individual homes exist to provide performance record of the aerobic units at that scale (4) Power is required to operate aeration equipments and pumps. (5) Sludge generated must be removed from aerobic unit and any clarification units. (6) Aeration equipment can be noisy and mechanical moving parts are subject to failure. (7) Aerobic units require special start-up procedures every time they are shut down due to the microbes that feed on the wastewater. This could be a problem, particularly for seasonal homes.	(1) A primary clarification unit (septic tank or trash trap) can be installed prior to the aerobic chamber to enhance the aerobic treatment process. (2) Ozones oxidation unit can be used as the aerobic unit but this process is still a developing technology and therefore expensive to use.	(1) Aerobic units must have regular, semi-skilled operation and maintenance to ensure proper functioning of moderately complex equipment, and inspections every 2 months. (2) Aerobic units must be readily accessible. (3) The restrictions pertaining to the various disposal systems were mentioned previously for the systems utilizing septic tank treatment and apply here with aerobic treatment units. (4) Power source is essential. (5) Public management required.
Aerobic Treatment Units/ Surface Discharge Biologically treated effluent from the aerobic treatment units	(1) Can be used where subsurface disposal systems are not feasible.	(1) Because the aerobic units are more prone to microbial upsets if not	(1) Disinfection methods available include tablet chlorination,	(1) Surface discharge must be permitted by the regulatory agency

Table 2. Continued

System	Advantages	Disadvantages	Modifications	Constraints
Aerobic Treatment Units/ Surface Discharge (Contd) is conveyed to a pumping chamber where it is pumped through an intermittent sand filter for polishing. Disinfection units are also incorporated when necessary prior to discharge to surface waters.	(2) Filter requirements (surface area, length of loading and resting periods, and maintenance) may be less than those for filters following a septic tank and still be able to maintain the same effluent quality. This is because the greater treatment capabilities of the aerobic units discharge a lower organic loading. (3) Aerobic treatment units are being produced by more manufacturers as self-contained package plants with various features incorporated into the design to reduce the need for frequent surveillance. (4) Relatively small space requirements.	maintained properly, variable quality effluent may be discharged to surface waters. (2) Construction costs and operation/maintenance costs are relatively high. (3) Few on-site installations for individual homes exist to provide performance record of the system at that scale. (4) Power is required to operate aeration equipment and pumps. (5) Sludge generated must be removed from aerobic unit and any clarification unit and filter surfaces must be maintained. (6) Aeration equipment can be noisy and mechanical moving parts are subject to failure. (7) Centralized management, rather than homeowners, is normally required for successful operation. (8) Potential odor problem from filters. (9) Public access may need to be restricted due to potential health hazard. (10) Chlorine disinfection can result in the production of toxic chlorinated organics in final effluent being discharged.	iodine crystals, and ultraviolet irradiation. (2) A primary clarification unit (septic tank or trash trap) can be installed prior to the aerobic chamber to enhance the aerobic treatment process. (3) Buried sand filters or recirculating sand filters can be used in place of the intermittent sand filter.	(state or federal permits). (2) A receiving surface water must available. (3) Sampling and monitoring system is required (4) Power source is essential. (5) Aerobic units must be readily available. (6) System must have regular, semi-skilled operation and maintence to ensure proper functioning of moderately complex equipment.

Table 2. Continued

System	Advantages	Disadvantages	Modifications	Constraints
In-house Wastewater Treatment and Recycle Waste stream from one or more household fixtures (graywater sources) are treated to provide the water supply for another use of specific water quality, such as flushing toilets and watering lawns. Treatment methods for recycle include ion exchange, aeration, absorption, clarification, filtration, and disinfection. A major option consists of a holding tank, filtration devices, a disinfection process, and a pump-pressure tank combination for supplying the treated water.	(1) Reduces the quantity of water used and/or wastewater generated which is suitable for increasing the life or improving the performance of on-site soil disposal systems.	(1) Involves semi-skilled to skilled labor, depending on system. (2) Operation and maintenance should be performed by centralized management personnel to prevent potential health risks. (3) Odors may be generated and water quality may be aesthetically objectionable when system malfunctions. (4) User acceptance may be difficult. (5) Few on-site installations existing to provide performance record.	(1) Recycled water can be dyed in some manner for aesthetic reasons.	(1) Remaining wastewater must still be treated because complete recycle-closed loop expensive to install and maintain.
Wastewater Segregation Waste streams are segregated into two components, blackwater (human excreta and garbage wastes) and graywater (wastewaters generated from fixtures other than toilets such as washing machines and sinks). The blackwater is usually handled by either non-water carriage toilets or the very low flush toilets with containment. The graywater requires treatment prior to disposal because it still contails significant levels of pollutants (pathogens). It is recommended that typical residential wastewater treatment/disposal systems (as listed previously) be used until further field data is available for describing graywater characteristics.	(1) The treatment/disposal system used for graywater is designed as a typical residential system but for a significantly reduced flow volume. (2) Non-water carriage toilets are non-discharging and can be used in areas where conventional treatment/disposal systems are not suitable.	(1) Construction costs are relatively high, particularly if the system is to be installed in a building previously constructed (retrofit). (2) Few on-site installations exist to provide performance record. (3) User acceptance may be difficult.	(1) Graywater streams may be handled by a community or regionalized system rather than on-site. (2) Four major options are available to handle blackwater streams. These are further described below.	(1) Two separate systems must be maintained to handle both graywater and blackwater streams.

Table 2. Continued

System	Advantages	Disadvantages	Modifications	Constraints
Options for Handling Blackwater Streams:				
(1) Recycling Oil Flush Toilet. A chemical fluid, generally mineral oil, is substituted for water as the flushing medium. Wastes and oil are separated by gravity in a storage tank. Oil is screened, filtered, and chlorinated before recycle. Typical residential system uses 20-30 gallons of oil. Storage tanks are placed under the house in basement or excavated areas. Periodic maintenance consists of annual dumping of solid wastes, addition of chlorine, addition of oil to maintain proper levels and replacement of oil filters.		(1) Possible problems with odors in dirty oil and disposal of residuals due to their oily character. (2) Relatively high operation and maintenance costs. (3) Systems are complex; efficient operation may be beyond capability of homeowner. (4) Mechanical equipment is subject to failure.		(1) Requires separate plumbing for toilet fixture and large area. (2) Needs a constant power supply.
(2) Incinerator Toilet. Small self-contained units which volatilize the organic components of blackwater and evaporate the liquids. Utilize electricity, natural gas or propane gas, or oil to incinerate the human wastes. Incineration cycle completed in 15-20 min. Exhaust fumes removed by vertical	(1) Soild wastes to be disposed are negligible in volume.	(1) High energy consumption. (2) More frequent maintenance of oil and gas fired than electric. (3) Potential odor, noise, and air pollution problem. (4) Relatively high operation and maintenance costs. (5) Systems are complex and subject to mechanical failure.		(1) Needs a constant power supply. (2) Set usage capacity to avoid overloading, less than 3 uses per hour. (3) Must treat graywater.

Table 2. Continued

System	Advantages	Disadvantages	Modifications	Constraints
vent and blower. Periodic maintenance consists of cleaning of the waste pan to remove inorganic ash (once a week), replacement of liners (electric only), and semi-annual cleaning and adjustment of burning assembly and/or heating elements.				
(3) Composting Toilet. Self-contained unit where wastes are transported by gravity or screw conveyers to ventilated fiberglass or polystyrene tanks Unit utilizes aerobic biological activity to stabilize wastes. Aerobic composting is for a period of 1 year to produce humus suitable for fertilizer. Maintenance includes periodic removal of composted humus (large unit, once per year and small unit, 4 times per year) and periodic maintenance of mechanical parts.	(1) Simple, low maintenance system. (2) Produces usable compost fertilizer.	(1) Possible odor problem and health hazard. (2) Possible problem with accumulation of flies that may require application of insecticide (must be careful not to harm necessary microorganisms). (3) May require separate waste disposal facilities for liquids.	(1) Can install either small (non-separated) units servicing one toilet to be placed entirely within the bathroom or a larger (separated) unit servicing several toilets and garbage chutes to be placed in a basement or excavated area.	(1) Set usage capacity to avoid overloading (small unit, less than 3 persons and large unit, less than 5 persons). (2) Must treat graywater.

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Table 3. Community Collection Systems

System	Advantages	Disadvantages	Modifications	Constraints
Small Diameter Gravity Sewers Wastewater from home is pretreated by individual septic tanks for the removal of solids, then conveyed by 4 to 6 inch pipe that is installed at a slope based on the design carrying load. Flows from each housing unit is then collected and transported to the treatment/disposal system downstream.	(1) Less installation problems compared to conventional gravity sewers. (2) System is not dependent upon moving parts. (3) Lower operation and maintenance costs than conventional 8-inch gravity sewers. (4) Septic tank settles out some solids and removes some scum, therefore flows to downstream system are less concentrated.	(1) More susceptible to operation and maintenance problems than conventional sewers. (2) Few installations existing to provide performance records. (3) Flows are increased due to infiltration/inflow from the collection system. (4) Sewage being conveyed is septic.	(1) Individual aerobic treatment unit can be used to replace the septic tanks.	(1) Cleanouts must be provided for sewers (large manholes not necessary). (2) Individual septic tanks are required by all users. (3) Must be allowed under state regulations.
Vacuum Sewers Wastewater from home is conveyed to a central vacuum station. A vacuum pump at the station creates a vacuum (at 15-25 inches of mercury) in collector pipe. At wastewater source, a valve opens when sewage presses against it. Sewage is then transported as a slug with a plug of air behind it which forces it through the collector pipes to a tank at the central vacuum station. When sufficient liquid volume accumulates in the tank a central sewage pump is used to transport it to the treatment/disposal system downstream.	(1) Less installation problems compared to conventional gravity sewers. (2) Less growth incurement because of less reserve capacity in sewer lines. (3) Minimal trench draining effect that is associated with sewer pipes in aquifer areas. (4) Deep manholes not necessary. (5) Low construction cost. (6) System doesn't require each user to have a septic tank.	(1) Limited to lift available, therefore more suitable to flat terrain. (2) Have a high cost per unit volume of sewage transported, therefore can be adversely affected by low initial use to design use ratio. (3) High operation and maintenance. (4) Few installations existing to provide performance records. (5) Flows are increased due to infiltration/inflow from the collection system. (6) Difficult to locate system malfunctions.		(1) Valves require yearly inspection. (2) Constant power supply is required for vacuum and sewage pumps. (3) Must be allowed under state regulations.

Table 3. Continued

System	Advantages	Disadvantages	Modifications	Constraints
Pressure Sewer, STEP (Septic Tank Effleunt Pump) Wastewater from home is pretreated by individual septic tanks for the removal of solids. Effluent then flows to a holding tank which houses the pressurization device, control sensors, and valves (normally use small submersible centrifugal pumps). Pump forces effluent through pipe to the treatment/disposal system downstream.	(1) Effectively treats wastewater on individual lots not suitable for on-site disposal (soil absorption fields). (2) Septic tank settles out some solids and removes some scum, therefore flows to downstream system are less concentrated. (3) Limited infiltration/inflow.	(1) Pumping components are more susceptible to operation and maintenance problems. (2) Few installations existing to provide performance records. (3) Septic tanks must be periodically pumped to remove accumulated sludge and scum. (4) Sewage being conveyed is septic.	(1) Cluster system can be incorporated where effluent from several septic tanks flow to one pumping tank. (2) Individual aerobic treatment units can be used to replace the septic tanks.	(1) Constant power supply is required for pumping. (2) Individual septic tanks are required by all users.
Pressure Sewer, GP (Grinder Pump) Wastewater from home flows to a storage tank on-site that houses a grinder pump. This can be installed in the basement of the home to provide easy access for maintenance and greater protection from vandalism. The unit grinds the sewage and pumps it through small-diameter plastic pipe to the treatment/disposal system downstream. It doesn't use a septic tank but any existing tank may be used as an emergency overflow tank.	(1) Effectively treats wastewater on individual lots not suitable for on-site disposal (soil absorption fields). (2) System doesn't require each user to have a septic tank. (3) Limited infiltration/inflow.	(1) Pumping components are more susceptible to operation and maintenance problems. (2) Flows for this system will be more concentrated due to all solids being ground rather than removed from the system.	(1) Cluster system can be incorporated where wastewater flows from several homes are ground and pumped by one unit.	(1) Constant power supply is required for grinder pump unit.

Table 4. Community Treatment/Disposal Systems

System	Advantages	Disadvantages	Modifications	Constraints
Community Soil Absorption System (bed or trenches) Wastewater flows from small diameter gravity sewers or from STEP systems and are transported to a nearby community soil absorption field. Since influent flows to be disposed are very large compared to individual units, dosing/pumping mechanisms are recommended for even distribution.	(1) Septic tank effluent from the individual units doesn't require further treatment. (2) Construction operation and maintenance costs are relatively low. (3) Bacteria and oxygen in the soil help purify the tank effluent.	(1) Land area requirements are very large. (2) Poor quality clarified effluent from individual septic tanks.	(1) Various systems available include: mound system if site has limiting zones such as high groundwater levels. ET or ETA beds if soils soils are not conducive for renovation of wastewaters. (2) Alternating soil absorption fields are highly recommended, particularly a three-field system in which each field contains 50 percent of the required absorption area. This allows the fields to rejuvenate and provides a standby field. (3) Absorption fields could be broken up into a series of smaller trenches or beds to help distribute the effluent over a wider area.	(1) Community soil absorption system requires large land area with soil conditions suitable to allow for proper percolation and absorption. The soil and site constraints listed for individual systems are the same for community systems. (2) Each user must have a septic tank or aerobic treatment unit. (3) Constant power supply is required for dosing/pumping equipment. (4) Bed system requires soils with sandy or coarse loamy texture and 50 percent greater bottom area than trench system.
Community Evaporation and Evaporation/Infiltration Lagoons/Percolation Ponds Wastewater flows from small diameter gravity sewers or from STEP systems and are transported to a nearby community lagoon.	(1) Effectively treats wastewater not conducive to the utilization of conventional soil absorption systems. (2) Utilizes meteorologic and climatologic factors for the operation of lagoon. (3) Construction, operation, and maintenance costs are relatively low.	(1) Additional pretreatment may be required depending on the wastewater characteristics (2) Lagoon must be periodically pumped to remove settled solids. (3) Potential odor problem and health hazard require public access restrictions. (4) Few installations existing to provide operating history. (5) Not demonstrated adequately.		(1) Local health ordinances may restrict use due to potential health hazard. (2) Annual evaporation rate should exceed the annual precipitation. (3) Land area requirements are a major factor.

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Table 4. Community Treatment/Disposal Systems

System	Advantages	Disadvantages	Modifications	Constraints
Multiple-Compartment Septic Tank/Soil Absorption Field System can either be two or more individual tanks installed in series or an arrangement where special tank sections are connected together into a unit having single end walls and two compartments (such as a unit of four precast tank sections combined into one tank having two compartments). Effluent from tank is then disposed and conveyed to a soil absorption disposal field. This systems includes a collection system which could be either a vacuum sewer system or a pressure sewer grinder pump system. Also recommended is a dosing/pumping system to provide even distribution of the septic tank effluent on the absorption field.	(1) Construction, operation, and maintenance similar to conventional individual septic tanks and individual soil absorption fields. (2) Relatively low construction and operation/maintenance costs. (3) Effectively treats wastewater on lots not suitable for individual treatment/disposal systems but that are near a site that is suitable and that is large enough to sustain the system.	(1) Design flow must be carefully estimated so system is not overloaded. (2) Commercial wastewaters may require special handling prior to septic tank such as grease removal for restuarant wastewaters and lint removal for laundry wastewaters. (3) Large land area requirements. (4) Failure to be handled by a greater impact than failure of a similar individual system. (5) Flows to be handled by the system may be significantly increased due to the infiltration into the collection system.	(1) Alternating soil absorption systems highly recommended particularly a three-field system in which each field contains 50 percent of the required absorption area. This not only allows the fields to rejuvenate but also provides a standby field (2) Absorption fields should be broken up into a series of smaller trenches or beds because this helps distribute the effluent over much wider areas. A long bed, broken into several shorter systems, each served by a pump or siphon, is preferred over two or more short parallel beds. (3) Utilization of an ET or an ETA disposal system is feasible but requires even larger land area. (4) Utilization of an aerobic treatment system (extended aeration) is well suited to replace septic tank treatment but will require a greater degree of operator attention due to its complexity.	(1) The soil and site constraints for soil absorption disposal system are the same as those for the individual systems listed previously. (2) Single, large area site must be available near the community to be serviced. (3) Constant power supply is required for dosing/pumping equipment and for collection/pumping system.

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Table 4. Continued

System	Advantages	Disadvantages	Modifications	Constraints
Aerated Lagoon/Spray Irrigation (slow rate) System System includes treatment of collected wastewaters to level required for spray irrigation. Minimum treatment consists of biological treatment by lagoon plus chlorination for fecal coliform control (less than 1000 MPN/100ml).	(1) Higher quality of effluent to be disposed. (2) Areas used as spray irrigation site can be agricultural or forest lands that can be sources of added revenue. (3) Bacteria and oxygen in the soil help purify the effluent while using it to fertilize the vegetation. (4) Effectively treats wastewater on lots not suitable for individual treatment/disposal systems.	(1) Lagoon must be periodically pumped (1 to 5 years) to remove settled solids. (2) Spray irrigation disposal has relatively high construction costs. (3) Potential odor problem and health hazard, therefore system requires a buffer zone and public access restrictions. (4) Land area requirements are very large. (5) Spray irrigation equipment to be operated and maintained by semi-skilled personnel.	(1) Aerated lagoon can be replaced by a facultative lagoon. This will lower the volume of sludge to be pumped and disposed. (2) Pre-chlorination of wastewaters entering lagoon to increase the efficiency of the lagoon. (3) Land application by rapid infiltration can be utilized in place of irrigation. This method applies lagoon effluent in controlled doses to sandy soil to break down the solids and purify the effluent. It requires less land area but soil must be able to handle large application rates, (rapid permability) and depth to groundwater should be at least 10 feet (lesser depths are acceptable where underdrainage is provided).	(1) Soil conditions must be suitable for land application of treated wastewater effluent. Depth of soil to groundwater should be two to three feet. Soil permability should be moderately slow to moderately rapid. (2) Land area requirements are based on the application rate (which is based on soil conditions) and are a major factor. (3) Slope of land should be less than 20 percent on cultivated land and less than 40 percent on non-cultivated land.
Package Plants/Surface Water Discharge Wastewater flows are collected and conveyed to the package plant for treatment. This plant is a prefabricated (or in easily assembled standard components) unit that normally is designed to handle flows less than 0.050 MGD (1.0 MGD plants	(1) If properly designed, operated and maintained the plant will provide a good quality secondary effluent. (2) Smaller land area requirements than a conventional treatment plant. (3) Smaller hydraulic head	(1) Requires a power source and has high power costs. (2) Requires a skilled operator and has relatively high operation costs. (3) Can have a significant noise pollution problem. (4) Sludge generated must	(1) Plants can be designed as a physical-chemical or a fixed growth system (trickling filters and rotating biological contractors). (2) Plant can be built underground to minimize adverse environmental impacts and susceptibility	(1) Constant power supply is required. (2) Skilled operator is required if a good quality secondary effluent is desired. (3) Surface discharge must be permitted by the regulatory agency (state or federal

Page 3 of 5

Table 4. Continued

System	Advantages	Disadvantages	Modifications	Constraints
are available). Plants are usually biological facilities employing an activated sludge process (extended aeration or contract stabilization) followed by chlorination. The effluent is then discharged into surface waters.	loss than a conventional treatment plant. (4) Fast and relatively low-cost field installations. (5) Reduced excess activated sludge. (6) Generally little or no odor. (7) Relatively low capital costs. (8) Can be used where subsurface disposal systems are not feasible. (9) Effectively treats wastewater on lots not suitable for individual treatment/disposal systems and where land application of treated effluents is not allowed.	be removed. (5) Chemicals may be necessary. (6) Mechanical parts are subject to failure. (7) Very sensitive to large variation in flows.	to storm damage in built-up areas.	permits). (4) A receiving surface water must be available. (5) Sampling and monitoring system is required. (6) Flow equalization is required prior to package plant units.
Marsh-Pond/Surface Water Discharge Wastewater flows are collected and discharged to a closed marsh or pond or combination marsh/pond system. Marsh vegetation assimilates available nutrients and organic contaminants. Pond allows effluent renovation and discharge to surface waters.	(1) Effectively treats wastewater where subsurface disposal systems are not feasible. (2) Relatively low construction, operating, and maintenance costs. (3) Potential habitat for fish and wildlife.	(1) Marsh or pond must be available and nearby or must be constructed. (2) Marsh crop needs harvesting annually. (3) Potential odor and fly problem and may require public access restrictions. (4) Few existing systems to provide performance records.	(1) Surface water discharge could be replaced by land application techniques if site is available and soil conditions suitable.	(1) Local health ordinanaces may restrict use due to potential health hazard. (2) A receiving surface water must be available. (3) Sampling and monitoring system is required.
Oxidation Ditch/Surface Water Discharge Wastewater flows are collected and conveyed to the ditch where they are introduced into a continuous channel, usually an oval, with rotary brushes which	(1) Realtively low construction, operating, and maintenance costs. (2) Easily operated and maintained. (3) Low power requirements.	(1) May require substantial land area. (2) Periodic sludge removal required from ditch. (3) Potential odor and	(1) Conventional activated sludge treatment may be practiced instead of the more common extended aeration process.	(1) Most applicable for wastewater flows between 0.1 and 10 mgd. (2) Requires semi-skilled labor for operation.

Table 4. Continued

System	Advantages	Disadvantages	Modifications	Constraints
aerate the wastewater and move the liquid around the channel. Aerobic microorganisms suspended in the wastewater metabolize and stabilize organic contaminants. Effluent is then chlorinated prior to surface water discharge. Treatment is actually a simplified form of the activated sludge process.	(4) Can handle, if designed properly, large variations in flow.	fly problems.	(2) "Ell" or "horseshoe" configurations may be constructed to maximize land usage.	

Table 5. Regional Collection System

System	Advantages	Disadvantages	Modifications	Constraints
Gravity Sewers Wastewaters from homes are collected by a larger diameter (greater than 6 Inches) pipe to be transported to downstream treatment/disposal system. Pipes flow due to gravity by proper slope design. Access to a gravity sewer is made by manholes every 300 to 500 feet or at changes in slope or direction.	(1) Oldest and most common wastewater transport system existing. (2) System is not dependent on moving parts such as pumping. (3) System has a long life expectancy. (4) Relatively low operation and maintenance costs.	(1) Relatively high construction costs in rural areas and flat areas where greater depths are required to achieve desired slopes. (2) Possible explosion hazard due to production of gas or improper discharge of combustibles into the system. (3) Flows are increased due to infiltration/inflow from the collection system particularly since conventional gravity sewers have more excess-volume available than small-diameter gravity sewers. (4) Stoppage of flow can occur due to grease, sedimentation, and tree-root development.	(1) Use inverted syphons or lift stations for hilly or excessively flat terrain. (2) Sewers can be sewage only or combined (includes storm runoff) (3) Several different. construction materials available and various construction methods are being utilized.	(1) Deep manholes are required.
Force Mains Wastewaters are conveyed under pressure from the discharge side of a pump or lift station to a point of gravity flow downstream. Wastewaters often first enter a storage well which serves as a suction well for the pump(s).	(1) System has been widely used and fully demonstrated. (2) Involves less land use disruption and construction costs than excessively deep sewering for gravity systems in many areas.	(1) Frequent cleaning and maintenance of force mains is required to remove slimes and solids buildup. (2) Relatively high construction, operation and maintenance costs. (3) Often the dissolved oxygen content of the wastewater is depleted in the storage well and results in a final discharge from the system of septic wastewater which is not only devoid of oxygen but often contains sulfides. (4) Pumping stations are subject to odors.	(1) Various pipe materials are available for use. (2) Mains may be aerated or the wastewater chlorinated to maintain freshness or prevent septicity. (3) Wye cleanouts can be installed on longer lines.	(1) Requires a gravity or pressure system to pick up flows from the individual sources. (2) Constant power supply is required for pumps.

Table 6. Regional Treatment/Disposal Systems

System	Advantages	Disadvantages	Modifications	Constraints
Aerated Lagoon/Spray Irrigation (Slow Rate) System System includes treatment of collected wastewaters to level required for spray irrigation. Minimum treatment consists of biological treatment by lagoon plus chlorination for local coliform control (less than 1000 PPN/100ml).	(1) Areas used as spray irrigation site can be agricultural or forest lands that can be sources of added revenue. (2) Bacteria and oxygen in the soil help purify the effluent while using it to fertilize the vegetation. (3) Effectively treats wastewater on lots not suitable for individual treatment/disposal systems. (4) Low construction, operating, and maintenance costs. (5) Existing installations in North Carolina have had good results.	(1) Lagoon must be periodically pumped (1 to 5 years) to remove settled solids. (2) Potential odor problem and health hazard, therefore system requires a buffer zone and public access restrictions. (3) Land area requirements are very large. (4) Spray irrigation equipment to be operated and maintained by semi-skilled personnel.	(1) Aerated lagoon can be mechanically aerated which would require more maintenance and have higher costs. (2) Aerated lagoon can be replaced by a facultative lagoon. This will lower the volume of sludge generated. (3) Pre-chlorination of wastewaters entering lagoon to increase the efficiency of the lagoon. (4) Lagoon can be divided into at least three cells to increase treatment efficiency. (5) Land application by rapid infiltration can be utilized in place of irrigation as described in the community systems. (6) Aerated lagoon can be replaced by an oxidation ditch.	(1) Soil conditions must be suitable for land application of treated wastewater effluent. Depth of soil to groundwater should be 2 to 3 feet. Soil permeability should be moderately slow to moderately rapid. (2) Land area requirements are based on the application rate (which is based on soil conditions) and are a major factor. (3) Slope of land should be less than 20 percent on cultivated land and less than 40 percent on noncultivated land.
Conventional Secondary Treatment Plant/Inland Surface Water Discharge Wastewaters collected are treated to secondary treatment levels by biological or physical/chemical processes and then chlorinated prior to discharge into a nearby receiving surface water. Advanced treatment may be added when required.	(1) High level of effluent. (2) Effectively treat wastewater where subsurface disposal systems or land application systems are not feasible. (3) Effectively treats wastewater on lots not suitable for individual treatment/disposal systems.	(1) High construction, operation and maintenance costs. (2) Requires a skilled operator. (3) Chemicals may be necessary. (4) Mechanical parts are subject to failure. (5) Sludge generated must be removed. (6) Surface water discharge to inland area may pose a problem.	(1) Conventional Secondary Treatment Systems include biological processes (activated sludge and trickling filters) and physical/chemical processes (sedimentation tanks and chemical precipitation processes).	(1) Constant power supply is required. (2) Skilled operator is required. (3) Surface discharge must be permitted by the regulatory agency (state or federal permits). (4) A receiving surface water must be available. (5) Sampling and monitoring system required.

Table 6. Continued

System	Advantages	Disadvantages	Modifications	Constraints
Conventional Secondary Treatment Plant/Ocean Outfall Wastewaters collected are treated to secondary treatment levels by biological or physical/chemcial processes and then chlorinated prior to discharge via ocean outfall.	(1) High level of effluent. (2) Effectively treats wastewater where surface disposal systems, land application, or surface water discharge (inland) are not feasible. (3) Effectively treats wastewater on lots not suitable for individual treatment/disposal systems.	(1) High construction operation, and maintenance costs particularly for the ocean outfall. (2) Requires a site-specific marginal study for evaluation of the impact the ocean outfall will have on the oceanic environment. (3) Requires a skilled operator. (4) Chemical additions may be necessary. (5) Mechanical parts are subject to failure. (6) Sludge generated must be removed. (7) Few existing installations of ocean outfalls for performance record.	(1) Conventional Secondary Treatment Systems include biological processes (activated sludge and trickling filters) and physical/chemical processes (sedimentation tanks and chemical precipitation processes). (2) Treatment could possibly be reduced to primary sedimentation plus chlorination provided a longer, deeper outfall is utilized and federal regulations relaxed.	(1) Constant power supply is required. (2) Skilled operator is required. (3) Ocean outfall must be permitted by the regualtory agency (state and federal permits). (4) Sampling and monitoring system is required. (5) In order for an ocean outfall to be economically feasible it must serve a substantial population.

Table 7. Sludge/Septage Handling and Disposal Systems

System	Advantages	Disadvantages	Modifications	Constraints
Sludge Storage The rentention and blending of thickened primary and secondary sludge in an open tank to reduce the pathogen population, further stabilize the sludge, equalize short-term peak loads, and to prepare sludge for either further processing or disposal.	(1) Improves capacity of disposal systems.	(1) Potential odor problem. (2) Temporary handling, requires ultimate disposal technique.	(1) Utilization of agitators for mixing. (2) Utilization of recycle for mixing. (3) Utilization of pure oxygen instead of air for aeration and mixing.	
Land Application of Sludge/Septage Liquid sludge, dried sludge and sludge cake are applied to the land by either injection, ridge and furrow spreading or spray irrigation. Consideration should be given to intermediate holding facilities before application to land. Also when utilizing the spray irrigation technique, portable pipes and nozzle guns are preferred to fixed or solid sets.	(1) Ridge and furrow method is well suited for relatively flat land and involves spreading sludge in the furrows and planting non-edible crops on the ridges. (2) Spray irrigation systems require less soil preparation than other methods and can also be used with a wider variety of crops. (3) All methods are relatively simple. (4) Sludge can act as a soil conditioner for agricultural, marginal, or drastically disturbed land.	(1) Land area requirements are large. (2) Equipment with standard tires can cause ruts, compacted soil and crop damage or get stuck in muddy terrain. (3) Potential odor and air pollution problems. (4) Public access to be restricted due to potential health hazard.		(1) Constituent of the sludge may limit the rate of application, the crop that can be grown, or the location of the site. (2) Steep slopes and low lying fields are less suitable. (3) Sampling and monitoring system to be established to guard against surface and groundwater contamination. (4) Spray irrigation necessitates a storage lagoon prior to disposal. Also a screening device at the lagoon's pump suction is mandatory.
Sludge Land Filling-Area Fill (Sanitary Landfills) Sludge is placed above the original earth cover and subsequently covered with soil to achieve stability and soil bearing capacity. Sludge is mixed with a bulking agent, usually soil. Installation of a liner	(1) Suitable when subsurface placement is impossible due to shallow groundwater or bedrock. (2) Area fill mound and dike containment have good land utilization. (3) Dike containment re-	(1) Utilizes large quantities of soil which may require hauling from elsewhere. (2) Stockpiled soil must be kept dry. (3) Few installations. existing for performance records.	(1) Co-disposal of sludge and refuse.	(1) Provisions must be made for surface drainage control, prevention of gas migration and explosion, dust and vector control, and/or aesthetics. (2) Mandatory installation of a storage lagoon or

Table 7. Continued

System	Advantages	Disadvantages	Modifications	Constraints
Sludge Land Filling-Area Fill (Sanitary Landfills) is generally required for groundwater protection. Area Fill Mound - six foot mounds of sludge/soil mixture followed by 5 feet of soil if additional mounds are placed on top or 3 feet if final soil cover. Area Fill Layer - Consecutive layers of sludge/soil mixture (0.5 to 3 feet thick) with interim cover of soil between layers (0.5 to 1 foot thick). Layering may continue to an indefinite height before final cover is applied Dike Containment - Dikes are constructed on level ground around all four sides of a containment area (steep slope of a hill can be utilized as one dike). Access is provided to the top of the dikes so that haul vehicles can dump sludge directly into containment. Interim soil covers (1-3 feet) can be applied and a final cover (3-5 feet) is applied when fill is discontinued.	quires less soil. (4) Techniques offer better odor and pest control than surface spreading techniques and the likelihood of inadvertent pathogen contamination to humans is greatly reduced.	(4) Area fill layer relatively land intensive. (5) Area fill mound has high manpower and equipment requirements due to the constant need to push and stack slumping mounds. (6) Rainfall causes mounds to slump. (7) Chemicals may be required for odor control. (8) Relatively higher capital costs due to costs of storage facilities and application equipment. (9) Ammonia volatilization is eliminated which reduces any nitrogen-loading safety factor from ammonia loss in surface spreading.		tank. (3) Leachate prevention and control facilities are highly recommended if rainfall exceeds 35 inches per year.
Sludge Landfilling - Sludge Trenching Sludge is placed within a subsurface excavation and covered with soil. Narrow trench-widths less than 10 feet.	(1) Has been fully demonstrated in existing installations. (2) Relatively simple to construct, operate,	(1) Precipitation can cause operating difficulties. (2) Potential soil erosion and odor problems. (3) Narrow trench method is	(1) Co-disposal of sludge and refuse.	(1) Require provisions for control of leachate and gas migration, dust, vectors, and/or aesthetics.

Table 7. Continued

System	Advantages	Disadvantages	Modifications	Constraints
Wide trench-widths greater than 10 feet. Width of trench is determined by the solids content of the sludge.	and maintain. (3) Narrow trench particularly well-suited for smaller communities. (4) Better odor and pest control than surface spreading and the likelihood of inadvertent pathogen contamination to humans is greatly reduced.	relatively more land intensive. (4) Relatively higher capital costs than surface spreading technique. (5) Ammonia volatilization is eliminated which reduces any nitrogen-loading safety factor from ammonia loss is surface spreading.		(2) Soil thickness must be maintained at 2 to 5 feet between trench bottom and seasonal high ground water level or bedrock (or can use a membrane liner and leachate collection/treatment system). (3) Mandatory installation of storage lagoon or tank.
Sludge Lagoons (Septage) Primarily designed to accomplish long-term drying of digested sludge through percolation and evaporation. Requires periodic removal of supernatant. Ultimate disposal of the solids is often as a soil conditioner or landfilling. System usually consists of earthen anaerobic-aerobic sludge digestion cells. Lime addition is suggested to maintain pH between 6.8 and 7.2.	(1) Relatively low construction, operating and maintenance costs. (2) Has been fully demonstrated in existing installations particularly smaller communities.	(1) Large land area requirements. (2) Temporary handling and requires ultimate disposal technique. (3) High potential for odors and insect breeding.	(1) Parallel sets of series lagoons are recommended.	(1) Sludge removal at 1.5 to 3 year intervals. (2) Requires a minimum of 2 cells. (3) Depth to groundwater should not be less than 4 feet.
Incineration Incineration using a combination of sludge and combustible material, other than natural gas or fuel oil, in a single furnace. Techniques include: Fluidized bed furnace Multiple hearth sludge.	(1) Provides a new low cost fuel service for existing sludge disposal facilities. (2) Uses same device to dispose of two waste products thereby being more cost-effective than separate incinerator. (3) Reduces land requirement for disposal. (4) May provide WTP with power.	(1) Requires excess air. (2) Potential air pollution problem due to particulates. (3) Relatively high construction, operation, and maintenance costs.	(1) Separate sludge incineration.	(1) Shredders are required to produce a nominal 1 inch refuse size. (2) Requires continuous power supply.

Table 7. Continued

System	Advantages	Disadvantages	Modifications	Constraints
Composting Sludge/Septage, Static Pile Wastewater sludge is aerobically converted to compost in approximately 8 weeks. Sludge is mixed with a bulking material and placed over porous pipe through which air is drawn and covered for insulation. After about 21 days of aerobic composting it is either dried or cured.	(1) Compost can be used as a low grade fertilizer, a soil amendment, or for land reclamation. (2) Utilizes aerobic metabolism of microbes to degrade sludge.	(1) Drying process is weather dependent (requires at least 2 rainless days). (2) Potential odor problems. (3) Potential human pathogen generation and aerosol distribution dictates careful attention to downwind land use.	(1) Extended high pile, used to save on space and materials. (2) Aerated extended pile, used to save on space and materials. (3) Window method - composting takes place on a surfaced outdoor area and air is supplied by periodic turnings.	(1) In order to use compost, pretreatment of industrial wastes is required. (2) Temperatures must remain above 140°F for composting.
Septage Treatment/Disposal Other methods not yet discussed include lime stabilization, chemical treatment/dewatering, and chlorine oxidation.	(1) Suitable for rural areas where land disposal is not feasible and no STP is available.	(1) High chemical requirements particularly chlorine oxidation.	(1) Disposal at Sewage Treatment Plants.	

APPENDIX C
WASTEWATER TREATMENT ALTERNATIVES ENGINEERING DESIGN CRITERIA*

System	Design Criteria		
Septic Tank/Soil Absorption Field (Unmodified)	Tank Capacity	flow 750-1500 gal/day - 1.5 times average daily flow flow 1500-15,000 gal/day minus 1.125 + 75% of average daily flow minimum soil depth of 4 ft. to limiting layer	
	Soil Absorption Field	Soil Percolation Min/In	Application Rate gpd/ft^2
		<1	not suitable
		1-5	1.2
		6-15	0.8
		16-30	0.6
		31-60	0.45
		61-120	0.2
Septic Tank/Sand Mound System	Tank Capacity	Min. 900-1000 gal	
	Mound System	0.25 - 1.2 gal/ft^2 24" natural suitable soil below sand	
Septic Tank/Artificially Drained System	Same as soil absorption field, must lower water table to get proper soil depth		
Septic Tank/Evapotranspiration Bed (ET)	Design based on the local annual weather cycle, use 10 year expectancy year to provide sufficient surface area		
Septic Tank/Polishing Surface Discharge	Sandfilter	Buried 0.75 to 1.5 gal/d/ft^2 Intermittant 5 gal/d/ft^2 Recirculating 3 gal/d/ft^2	
Aerobic Treatment Units/Non-Surface Disposal:	Design flow	75 gal/d/person	
	Mixing Requirements	0.5 to 1.0 hp/1000 ft^3	
	Oxygen Requirements	0.2 to 1.0 O_2/hp hr	

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*The specific design driteria listed have been extracted from detailed technical descriptions contained in the source document. P. 113.

Source: USEPA. 1980. Design Manual: Onsite Wastewater Treatment and Disposal Systems.

WASTEWATER TREATMENT ALTERNATIVES ENGINEERING DESIGN CRITERIA

System	Design Criteria	
	Weir Overflow rates	peak <800 gpd/ft average 200-400 gpd/ft
	Absorption areas same as soil absorption field	
Aerobic Treatment Units/Surface Disposal:	Design flow	75 gal/d/person
	Mixing Requirements	0.5 to 1.0 hp/1000 ft^3
	Oxygen Requirements	0.2 to 1.0 O_2/hp hr
	Weir Overflow rates	peak <800 gpd/ft average 200-400 gpd/ft
	Sand filter	sand size 0.2 to 0.6 mm uniformity coefficient 4.0
Holding Tank	7 days storage at average flow	1000 gal minimum
In House Waste-Water Treatment and Recycle	Reuse Water Quality Criteria	

Reuse	Water Quality BOD mg/l	SS mg/l	Turbidity TU
Toilet Flushing	20	20	25
Utility Water	15	15	20
Body Contact	10	10	1

System	Design Criteria
Wastewater Segreation	Same total disposal area required, black water can go to the most desirable disposal site.
Options for Handling Blackwater Stream	Dispose as normal septic tank effluent.
Community Soil Absorption System	Hydraulic Loading Rate 0.25-1.2 gpd/ft^2

Soil Percolation Min/In	Application Rate gpd/ft^2
<1	not suitable
1-5	1.2
6-15	0.8
16-30	0.6
31-60	0.45
61-120	0.2

System	Design Criteria
Community Evaporation Infiltration Lagoons	Design flow 50-75 gals/person/day Detention time 7 to 50 days pH 6.5 - 10.5 Temperature Range 0 to 50°C
Multiple Compartment Septic Tank/Soil Absorption Field	Second compartment 1/3 to 1/4 the length of standard septic tank

WASTEWATER TREATMENT ALTERNATIVES ENGINEERING DESIGN CRITERIA

System	Design Criteria	
		Soil absorption criteria: same as standard septic tank absorption field
Aerated Lagoon/ Spray Irrigation System	Lagoon	Detention time 3 to 10 days Depth 6 to 20 ft pH 6.5 to 8.0 Temp 0 to 40°C (optimum, 20°C) Oxygen requirement 0.7 to 1.4 times BOD removed Organic Loading 10-300 lb BOD/Ac/D
	Irrigation	Area 56 to 560 ac/mg/day Application 2 to 20 ft/yr Rate: 0.5 to 4.0 in/wk Soil Depth 2 ft Soil Permeability 0.06 in/hr
Package Plant Surface Water Discharge (extended aeration plant)	Volumetric loading 16 BOD/d/1000ft^3 5 to 10 MLSS, mg/l 3000 to 6000 F/M, 165 BOD/d/lb MLUSS 0.05 to 0.15 Detention time hours 18-36 Std ft^3 air/lb BOD applied 3000 to 4000 Sludge retention time days 20 to 40 Recycle Ratio 0.75 to 1.5 Volatile fraction of MLSS 0.6 to 0.7	
Marsh-Pond/Surface Water Discharge	Detention Time 13 days Flow depth 1-5 ft Surface area 8 ac/mg/day	
Oxidation Ditch/ Surface Water Discharge	BOD loading 8.6 to 15 lb/1000 ft^3 aeration vol/d Channel depth 4 to 6 fgt Channel shape 45 to 90 degree side walls Detention time 1 day Sludge age 10 to 33 days	
Convention Secondary Treatment Plant/Inland Surface Water Discharge	Volumetric loding, 16 BOD/d/1000 ft^3 25-50 Aeration time, hr 4-8 MLSS, mg/l 1500-3000 F/M, 16 BOD/d/lb MLUSS 0.25-0.5 Air Requirements Std ft/lb BOD removed 800-1500 Sludge Retention time, days 5-10	
Sludge Storage	Tank floor slope 1:12 Mixing: air diffusion 25 ft^3/min/1000 ft^3 Mechanical 1.0 hp/1000 ft^3	
Land Application of Sludge:	Application rates based on N,P,K Disposal: 0.5 to 100 tons/acre Crop Nitrogen Requirements: 5 to 10 tons/acre	

WASTEWATER TREATMENT ALTERNATIVES ENGINEERING
DESIGN CRITERIA

System	Design Criteria
Sludge Land Filling/Area Fill:	Sludge, application rates: >20% Solids 3,000 to 14,000 yd^3/ac >15% Solids 2000-9000 yd^3/ac
Sludge Land Filling/Sludge Trenching:	Trench Widths: < 10 ft 1200 to 5600 yd^3/ac 10 ft 3200 to 14500 yd^3/ac
Sludge Lagoons:	Side slopes: exterior 1:2 interior 1:3 Depth of Sludge ft 1.5 - 4.0 Pounds of solids 2.2-2.4 lb solids/yr/ft^3
Co-Incineration	Sludge dewatering 20-30% solids
Composting Sludge/ Septic Static Pile	Air Flow 100/ft^3/h/ton of sludge Land requirement 0.3 - 5 c/dry ton
Septage Treatment and Disposal	Lime stabilization

Sludge - percent solids	1	2	3	4
pH=11 $Ca(OH)_2$ dosage mg/l	1400	2500	3700	5200
pH=12 $Ca(OH)_2$ dosage mg/l	2600	4300	5000	9500

APPENDIX D

ESTIMATION OF THE WATER TABLE ELEVATION ON A HYPOTHETICAL BARRIER ISLAND

The purpose of this appendix is to illustrate the specific methodologies used for predicting water table response to wastewater additions by applying the methodologies to a hypothetical barrier island case study. The methodologies are described in Section 4.2.2.3 of the Alternatives Development Report.

Before the hydrogeologic and climatic data were determined, a base map was used (Alternatives Evaluation Task Report, Figure 2.3.2.1) to determine island half-width. A schematic diagram showing island half-width and interval spacing is shown in Figure D.1.

Hydrogeologic and climatic data used in the case study were abstracted from standard reference sources to represent average environmental conditions on barrier islands. Monthly normal precipitation and temperature came from the Wilmington, North Carolina, climatic station. No abstraction was made for extreme tropical storms occurring in June, July and August. Based on a 100 year record, 27 thunderstorms or tropical storms occurred in these three months; if all 27 events had been deleted, the normal monthly precipitation for June, July and August would be somewhat lower. Also, there was no abstraction for direct runoff because it was assumed to be non-existent on the island. This assumption would probably be invalid in highly developed areas where impervious surfaces and storm sewering are common.

Monthly evapotranspiration (Ep) was estimated empirically using the relationship developed by Holdridge (Lee 1980):

$$Ep = 0.189 \times T_b$$

T_b = mean daily air temperature (°C) above 0° Centigrade.

Table D.1 summarizes the climatic data.

Wastewater recharge to the island was based on maximum seasonal occupancy. Assuming five units per acre, eight persons per unit and 75 gallons of effluent per person per day, the maximum effluent generated per acre per month was calculated. Maximum island occupancy was assumed for May through August to correspond to summer periods of peak tourism; a value of 1/5 the maximum was assumed for the remaining months. This approach is conservative because maximum occupancy results in a greater water table rise. The final monthly recharge was obtained by subtracting evapotranspiration from precipitation and adding wastewater disposal (Table D.1). The average monthly recharge to the hypothetical island is 2.58 inches, and the average daily recharge to the island is 0.08 inches.

There is a wide-ranging continuum of conductivity values for unconsolidated sediments because conductivity is partly a function of the size of the pore opening. The water table aquifer in this case study was assumed to primarily consist of sands and clays. This aquifer type has conductivity values that typically range from 25 feet per day to 200 feet per day (Fetter

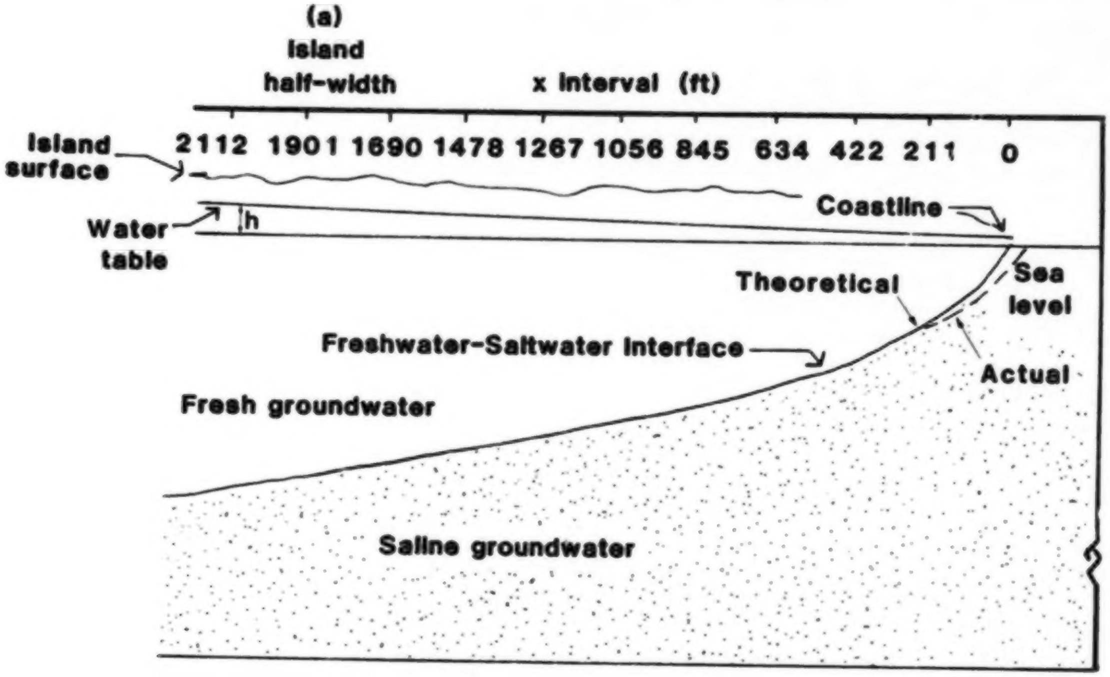

(a)
Island
half-width
x interval (ft)
Island
surface
2112 1901 1690 1478 1267 1056 845 634 422 211 0
Coastline
Water
table
h
Theoretical
Sea
level
Freshwater-Saltwater Interface
Actual
Fresh groundwater
Saline groundwater

Figure D.1. Schematic diagram showing island half-width and interval spacing used in the groundwater resource case study (Section 2.1)

Source: Claude Terry & Associates, Inc. 1982.

Table D.1. Summary of the Climatic Data Used to Evaluate Wastewater Impacts to Groundwater Resources.

Month	Precipitation (inches)	Temperature (° C)	Evapotranspiration (inches)	Wastewater Addition (inches)	Total Recharge (inches)
JAN	2.85	8.15	1.54	0.67	1.98
FEB	3.42	8.65	1.63	0.67	2.46
MAR	4.03	11.78	2.23	0.67	2.47
APR	2.86	16.53	3.12	0.67	0.41
MAY	3.54	21.12	3.99	3.37	2.92
JUN	4.26	25.22	4.77	3.37	2.86
JUL	7.68	26.57	5.02	3.37	6.03
AUG	6.86	26.28	4.97	3.37	5.26
SEP	6.29	23.90	4.52	0.67	2.44
OCT	3.01	18.22	3.44	0.67	0.24
NOV	3.09	12.40	2.34	0.67	1.42
DEC	3.42	8.34	1.58	0.67	2.51
YEAR	51.31	17.26	39.50	18.84	31.00

Source: N. C. Office of State Budget and Management Research and Planning Services, 1979. Claude Terry & Associates, Inc. 1982.

1980); a value of 50 feet per day was selected as the initial conductivity value. This selection is conservative because resulting water table elevations are higher when using the lower end of the conductivity range.

The data for the island were then used to determine the existing water table profile for the island half-width by applying the equation developed by Fetter (1971). The derivation of Fetter's equation is based on the Ghyber-Herzberg principle (Fettery 1980). The equation is

$$h^2 = \frac{w(a^2 - (a - x)^2)}{k\ (41)}$$

where

w = 0.01 ft/day
a = 2112 ft
x = 211 ft, 422 ft. . . and 2112 ft; 211 ft = interval
k = 50 ft/day

The results of the initial analyses are listed in Table D.2. This table gives the water table profile where 1) maximum occupancy is assumed and 2) no occupancy is assumed. Figure D.2 shows the cross-section of these profiles for the hypothetical barrier island. To demonstrate how the results might be used as a wastewater management tool, it is assumed that the island surface is 4 feet above mean sea level at a point 1056 feet from the coast (Figure D.1). If a drain field trench at this point is placed one foot into the surface horizon, physical contact between the water table and the trench would occur (Table D.2). However, if the surface of the island at the same point is six feet above mean sea level, physical contact would not occur.

The analytical solution presented in Table D.2 does not consider individual storm events or monthly variations in groundwater storage; the water table profiles in Table D.2 are based solely on the average daily recharge. However, individual storm events do not significantly affect the water table profile. For instance, a four-inch rainfall occurring in one day will increase the total depth of the aquifer one foot. The Gyhben-Herzberg principle states that the depth to which freshwater in coastal aquifers extends below sea level is 40 times the height of the water table above sea level. Thus, the height of the water table increases 0.03 feet after reaching equilibrium which is approached quickly. After one day the increase in total aquifer depth is approximately 0.24 feet, a 76 percent reduction from the initial increase. The increase in water table height after an additional day is 0.17 feet, an 83 percent reduction from the initial increase. After four days the total depth of the aquifer returns to a 1/40 of the initial increase or 0.025 feet in this case (Table D.3). On barrier islands where impermeable subsurface layers exist, infiltrated rainfall would percolate horizontally under a low hydraulic gradient. Under this condition the analytical solution would under-estimate the water table elevation. This analysis assumes consistent hydraulic conductivities with depth.

Carryover effects in aquifer storage from month to month are apparent; four inches of rainfall will increase total storage across a 2112 foot section of aquifer 704 ft^3. Because the change in storage is positive, the groundwater discharge into the ocean will increase 1.59 cu ft per ft of shoreline during the first day. This increase is caused by the greater head exerted by the additional water applied to the water table. Thus, the

Table D.2. Water Table Profiles for the Hypothetical Barrier Island under 1) Maximum Occupancy and 2) No Occupancy.

Distance from Shore-Line (ft)	Water Table Elevation Above Mean Sea Level (ft)	
	Maximum Occupancy	No Occupancy
211	1.72	1.07
422	2.37	1.47
634	2.82	1.75
845	3.16	1.96
1056	3.42	2.12
1267	3.62	2.25
1478	3.77	2.34
1690	3.87	2.40
1901	3.93	2.44
2112	3.95	2.45

Source: Claude Terry & Associates, Inc. 1982.

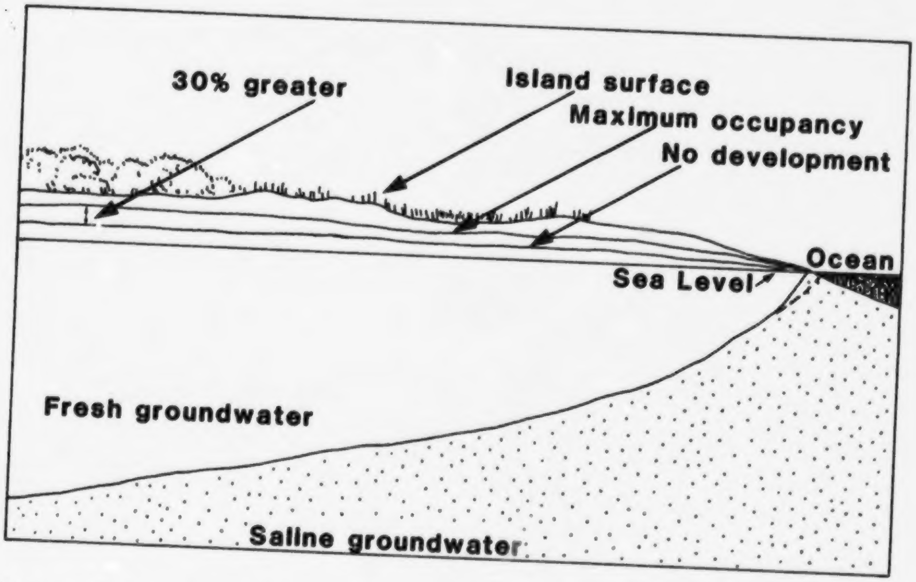

30% greater
Island surface
Maximum occupancy
No development
Ocean
Sea Level
Fresh groundwater
Saline groundwater

Figure D.2. Position of the water table for the hypothetical barrier island under 1) maximum development and 2) no development.

Source: Claude Terry & Associates, Inc. 1982.

Table D.3. The Hydrodynamic Response of the Unconfined Aquifer to a Four Inch Rainfall Occurring in One Day.

Time (Hours)	Rise in Water Table (ft)	Seepage Velocity (ft/day)
0	1.00	0.76
1	0.97	0.74
2	0.94	0.71
3	0.91	0.69
5	0.85	0.65
8	0.77	0.59
12	0.67	0.51
16	0.59	0.45
24	0.24	0.17
48	0.07	0.04
72	0.03	0.01
96	0.025	0.00

Notes:

Porosity = 0.33

Initial Aquifer Thickness = 200 ft

Hydraulic Conductivity = 50 ft/day

Source: Claude Terry & Associates, Inc. 1982.

additional rainfall in storage reduces to 702.41 ft^3 after 24 hours. After 20 days the additional rainfall in storage is 677.58 ft^3 (Table D.4). As a result, additional recharge remains in storage for several months at the very least. However, this carryover effect in storage is insignificant because only 1/40 of the accrued recharge adds to the height of the water table. The effect of this is to significantly lessen the impact of drought or heavy rainfall.

Seepage velocity in the zone of saturation occurs in response to a change in the elevation of the water table with distance. This change with distance is called the hydraulic gradient (I). Seepage velocity is described as

$$V_s = \frac{KI}{P}$$

where p is the porosity of the aquifer material and K is conductivity.

The water table for maximum occupancy (Table D.2) steepens as the coastline is approached. As a result, the hydraulic gradient and seepage velocity are greatest near the coastline. Thus, the time it takes effluent to move a certain distance is at a maximum near the island midpoint and at a minimum close to the coastline. Table D.5 gives the seepage velocity and resulting time of travel for selected distance intervals associated with the water table profile for maximum occupancy.

When considering septic system placement on the hypothetical barrier island, the time of travel to the nearest surface water body is most important near the ocean. If a septic tank system is located 100 feet from the ocean, then the septic tank effluent would reach the surface water body in 78 days. (This figure is reached by summing the first seven entries in Table D 5).

If the system is located at the island midpoint, travel time for the first 100 feet from the point of origin is 5000 days. Travel times for these two examples decrease to 28 days and 1,650 days respectively if the hydraulic conductivity is 200 feet per day instead of 50 feet per day (Table D.6). Individual storm events affect these travel times very little because only 1/40 of the rainfall adds to the height of the water table. Short-circuiting of wastewater through channels in the soil can appreciably reduce travel times. Proper soils and design must be used to avoid short-circuiting.

Existing soils on most barrier islands are quartz sands. These sands have a very high permeability and a low absorptive capacity to remove pollutants. However, if a septic tank is located 100 feet from a surface water body, which complies with North Carolina law, a public health hazard is unlikely because existing seepage velocities are slow. Intensive field studies should, however, be completed before evaluating any optimum set-back distance and careful consideration of soils and design should be given.

The water table responses and yearly deviations were based, in part, on the assumption that aquifer conductivity across the island is constant. Actually conductivity varies, depending on actual field conditions, throughout barrier islands. Thus, it is important to consider the response of the water table to changes in conductivity. To consider this response, the water table

Table D.4. Time Release in Storage in an Unconfined Aquifer after a Four Inch Rainfall Occurring in One Day.

Time (Days)	Hydraulic Gradient	Discharge (ft^3/ft shoreline/day)	Change in Discharge (ft^3/day)	Storage (ft^3)
Initial	3.93	130.47	1.59	704.00
1	3.96	132.06	1.33	702.41
2	3.96	131.80	1.33	701.07
3	3.96	131.80	1.32	699.74
4	3.96	131.79	1.32	698.42
5	3.96	131.79	1.32	697.10
6	3.96	131.79	1.32	695.78
7	3.95	131.79	1.32	694.46
8	3.95	131.78	1.31	693.15
9	3.95	131.78	1.31	691.84
10	3.95	131.78	1.31	690.53
11	3.95	131.78	1.31	689.22
12	3.95	131.77	1.30	687.92
13	3.95	131.77	1.30	686.62
14	3.95	131.77	1.30	685.32
15	3.95	131.77	1.30	684.02
16	3.95	131.76	1.29	682.73
17	3.95	131.76	1.29	681.44
18	3.95	131.76	1.29	680.15
19	3.95	131.76	1.29	677.58
20	3.95	131.75	1.28	677.58

Notes: Porosity = 0.33
Hydraulic conductivity - 50 ft/day
Aquifer length = 2112 feet

Source: Claude Terry & Associates, Inc. 1982.

Table D.5. Seepage Velocity and Time of Travel within Distance Intervals for the Barrier Island Case Study.

Distance Interval (feet)	Seepage Velocity (Ft/day)	Time of Travel (days)
0-15	4.75	3
15-30	1.92	8
30-45	1.52	10
45-60	1.21	12
60-75	1.11	14
75-90	1.01	15
90-105	0.91	17
105-120	0.81	19
120-135	0.81	19
135-150	0.71	21
150-200	0.67	75
200-300	0.53	188
300-400	0.42	236
400-500	0.36	275
500-600	0.32	313
600-700	0.27	370
700-800	0.23	435
800-900	0.21	476
900-1000	0.20	500
1000-1100	0.17	588
1100-1200	0.14	714
1200-1300	0.14	714
1300-1400	0.11	909
1400-1500	0.09	1,111
1500-1600	.08	1,250
1600-1700	.06	1,667
1700-1800	.06	1,667
1800-1900	.03	3,333
1900-2000	.02	5,000
2000-2100	.02	5,000

NOTES: Hydraulic conductivity = 50 ft/day
Porosity = 0.33

Source: Claude Terry & Associates, Inc. 1982.

Table D.6. Time of Travel within Distance Intervals for the Barrier Island Case Study When the Hydraulic Conductivity is Equal to 50 Ft/day and 200 Ft/day.

Distance Interval (Feet)	Time of Travel (days)	
	if 50 ft/day	if 200 ft/day
0-100	78	28
100-200	151	69
200-300	188	97
300-400	236	110
400-500	275	138
500-600	313	165
600-700	370	183
700-800	435	206
800-900	476	236
900-1000	500	275
1000-1100	588	330
1100-1200	714	413
1200-1300	714	413
1400-1500	1,111	550
1500-1600	1,250	550
1600-1700	1,667	825
1700-1800	1,667	1,650
1800-1900	3,333	1,650
1900-2000	5,000	1,650
2000-2100	5,000	1,650

Source: Claude Terry & Associates, Inc. 1982

position across the island was calculated again with conductivity changed from 50 feet per day to 100 feet per day (Table D.7). The calculation reveals a 30 percent decrease in the water table position resulting from a 100 percent increase in conductivity. This calculation indicates that small variations in conductivity will not significantly change estimates of the water table position. Thus, in areas of similar geology, it may be reasonable to assume a constant conductivity value.

The analytical solution presented in Section 4.2.2.3 of the Technical Reference Document, Alternatives Development Report, was applied to the case study island to reveal its applicability and usefulness. The data used in this study should be calibrated to reflect actual field conditions as accurately as possible. Seasonal variations in groundwater storage are highly correlated with the climatic balance between precipitation, evapotranspiration and wastewater disposal, but individual storm events and carryover effects in storage from month to month do not significantly influence the water table elevation as presented in Table D.2. Thus, the procedures illustrated in this section are useful in predicting the hydrodynamic response of the water table to wastewater disposal. The water table response to wastewatericantly influence the water table elevation as presented in Table D.2. Thus, the procedures illustrated in this section are useful in predicting the hydrodynamic response of the water table to wastewater disposal. The water table response to wastewater disposal on irregularly shaped oceanic islands can be more closely approximated through digital computer programs. Fetter (1971) developed such a model where conductivity can be varied spatially to correspond with actual field conditions and total recharge can be varied to reflect spatial variations in precipitation, evapotranspiration and wastewater disposal.

Table D.7. Comparison of Water Tables Profiles When Conductivity (K) Is Changed from 50 Ft/Day to 100 Ft/Day.

Distance from Shore-Line (ft)	Water Table Elevation Above Mean Sea Level (ft)	
	50	100
211	1.72	1.22
422	2.37	1.68
634	2.82	1.99
845	3.16	2.23
1056	3.42	2.42
1267	3.62	2.56
1478	3.77	2.66
1690	3.87	2.74
1901	3.93	2.78
2112	3.95	2.79

Source: Claude Terry & Associates, Inc. 1982.

APPENDIX E.

RESIDENTIAL DENSITIES RESULTING FROM THE USE OF SOIL ABSORPTION SYSTEMS

An analysis was made addressing the impacts on development densities of the widespread use of soil absorption systems, particularly in light of the North Carolina soil absorption system regulations which became effective July 1, 1982. Development densities for both single family and multi-family residences were examined.

Single Family Residential

Based on the asumptions listed on the following figures regarding public water and building setback requirements, it would appear that there will be few problems with building on small 5,000 and 7,500 square foot lots. However, these areas are of insufficient size if nearby individual wells are utilized for water supply. The presence of wells would require 1/5 to 1/4 acre minimum lots to have adequate area for a separate replacement system and still satisify the 100 foot isolation requirement from nearby wells. Utilizing 5,000 square foot lots with seepage beds leads to essentially no replacement area for repairing a malfunctioning system by conventional techniques. Lots platted prior to January 1, 1983, may be exempt under certain provisions of the 1982 rule from providing a replacement area. Nevertheless, some developers are seriously considering small community/cluster systems for new single family development (Rubin 1982).

Three single family residential examples were developed using the following criteria:

Structure: 4 bedrooms; two stories; each floor area 30' x 30'; public water supply.

Sewage flows (ref. .1949): 120 gpd per bedroom resulting in a total flow of 480 gpd.

Septic tank capacity (ref. .1952(b)): minimum liquid capacity is 1000 gal. (2 compartment) per 4 bedroom dwelling.

Wastewater application rate (ref. .1955, table II): conventional septic tank absorption system; trenches or beds; soil type: sands to loamy sands. Appropriate rate is 1.2-.08 gpd/ft^2; use 1.0 gpd/ft^2.

Required nitrification area:

Trenches: total sewage flow - application rate
480 gpd - 1.0 gpd/ft^2 = 480 ft^2 of bottom area.
Assume 240 linear feet of 2 ft. wide trenches on 6 ft. centers giving a total trench area of 1440 ft^2 (i.e., 3x the trench width).

Bed: Section .1955(d) requires that the trench bottom area be increased by 50 percent to calculate bed area. Therefore, 480 ft2x1.5 (factor) = 730 ft^2 bed.

NOTE: Seepage beds can only be used on lots where it is impossible to construct trenches. (This requires the approval of the local health department.)

Figure E-1 is a diagram of a 5000 square foot lot platted prior to January 1, 1983. Figure E-2 is a 7500 square foot single-family residential lot, presently the minimum size permitted by law for a system using a seepage bed. Figures E-3 and E-4 show minimum lot sizes for single-family residences using trench and low pressure pipe systems, respectively. Figure E-5 shows a 10,500 square foot lot which is calculated to be approximately the minimum size lot developable with a soil absorption system if an individual water well must be provided.

Where local zoning ordinances require setbacks different from those shown, adjustments in lot dimensions must be made. Thus, it appears that for those lots platted prior to January 1983, five units per acre is a feasible density in communities with public water supplies, and four units per acre is reasonable in areas with private water supplies.

These densities could not be achieved in areas where soils are less permeable. Allowable wastewater application rates are 25 percent lower for coarse loams and 50 percent lower for fine loams. Therefore, trenches and beds larger than those shown in the preceeding figures would be required.

Section .1949(a) states that when a unit exceeds two persons/bedroom, the volume of sewage shall be determined by the maximum occupancy at a rate of 60 gallons per person per day. Seasonally occupied units tend to run higher than standard occupancy rates, and local health departments may therefore opt to require larger nitrification areas than standard. Such requirements may lead to the need to increase lot sizes.

Townhouses

A low density multifamily development containing six two-bedroom townhouses per acre was designed. Parking was assumed under the buildings and adequate space for a pool and tennis court could be expected if given a five or six acre tract. (Higher densities might be achieved if the amenities package was reduced.) The following design criteria apply:

Sewage flows: 120 gpd per bedroom results in 240 gpd per unit or 1440 gpd per acre (Q).

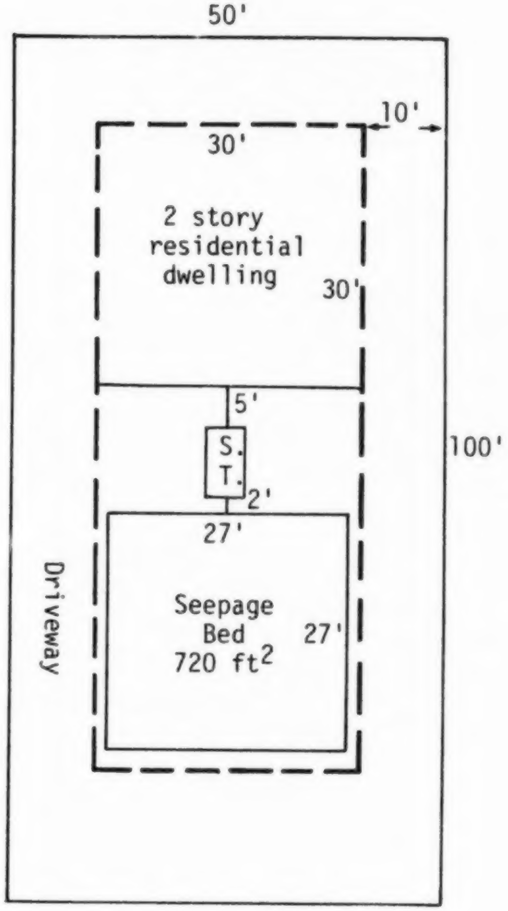
Septic tank capacity: $1.17\ (Q) + 500$
$1.17\ (1440) + 500 = 2185$ gallons
Use one 1500 gallon tank and one 900 gallon tank.

Required nitrification area:

Trenches: 1400 gals. - 1.0 gpd/ft^2 = 1440 ft^2 of trench bottom area
Assume 480 linear ft of 3 ft wide trenches on 9 ft centers giving a total trench area of approximately 4000 ft^2.

Bed: trench bottom area x 1.5
$1440 \times 1.5 = 2160$ ft^2 bed area

NOTE: Beds can only be used when site conditions prohibit the use of trenches. Their use must be approved by the local health department.


50'
10'
30'
2 story residential dwelling
30'
5'
S. T.
2'
100'
27'
Driveway
Seepage Bed 720 ft²
27'

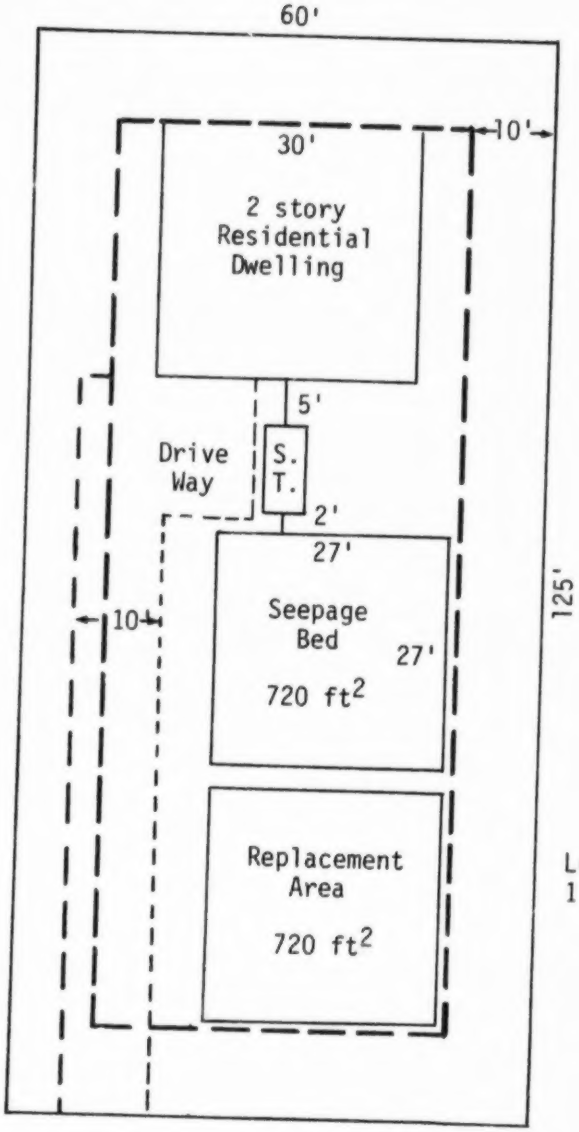
Lot Size = 5,000 sq. ft.
1 inch = 20 feet

Assumptions

a) Public Water Supply
b) Lot platted prior to January 1, 1983 may be exempt from reserve area requirement. If the requirement is imposed by the local health department, minimum lot dimensions would be 50' x 120'.
c) Proposed ground absorption area determined to be "suitable."
d) Building setback requirements do not exist.
e) Wells, canals, marshes, etc. on adjoining land must meet isolation distance requirements.

Figure E-1. Single family residence on 5,000 ft^2 lot

Source: Gannett Fleming Corddry and Carpenter, Inc. 1982.


60'
30'
10'
2 story
Residential
Dwelling
5'
Drive
Way
S.
T.
2'
27'
Seepage
Bed
27'
720 ft²
10
125'
Replacement
Area
720 ft²

Lot Size = 7,500 sq. ft.
1 inch = 20 feet

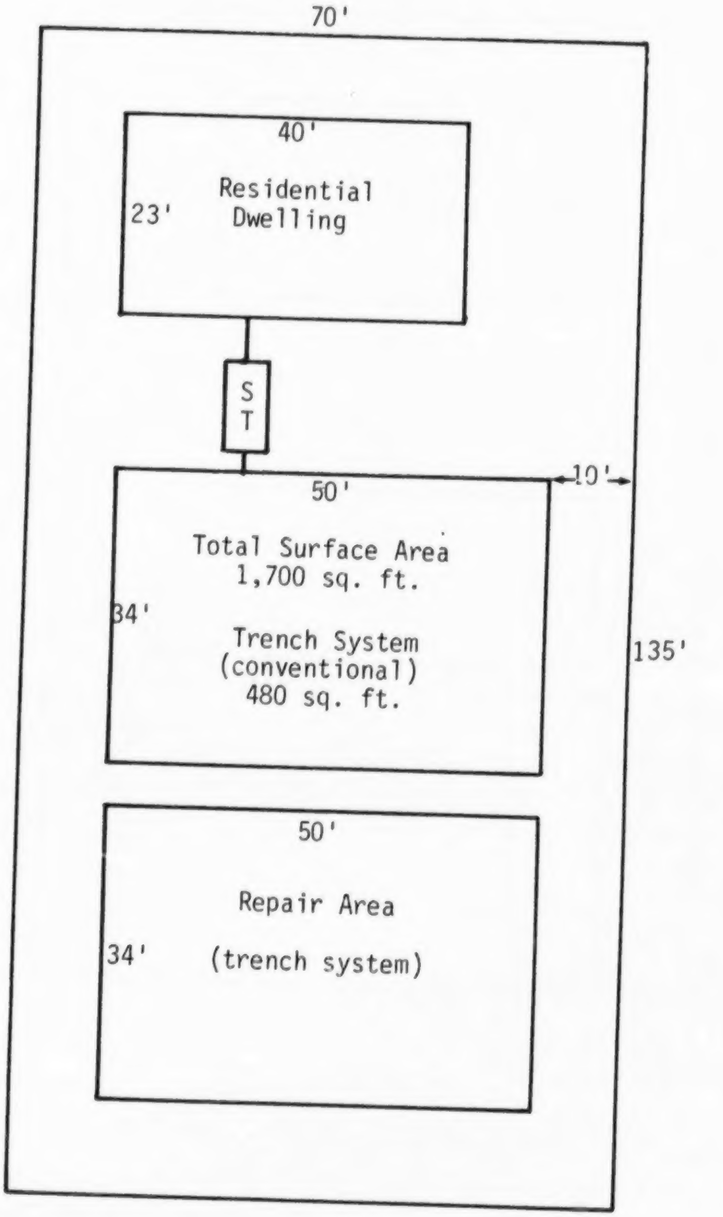
Assumptions:

a) Served by public water system
b) Proposed ground (soil) absorption area rated suitable
c) No building setback requirements exist
d) Parcel required to have a reserve area
e) Soils are sandy textured and homogenous

Note: Repair/reserve area is OFF-LIMITS to construction of any nature

Figure E-2. Single family residence on 7,500 ft^2 lot

Source: Gannett Fleming Corddry and Carpenter, Inc. 1982


70'
40'
Residential
Dwelling
23'
S
T
10'
50'
Total Surface Area
1,700 sq. ft.
34'
Trench System
(conventional)
480 sq. ft.
135'
50'
Repair Area
34'
(trench system)

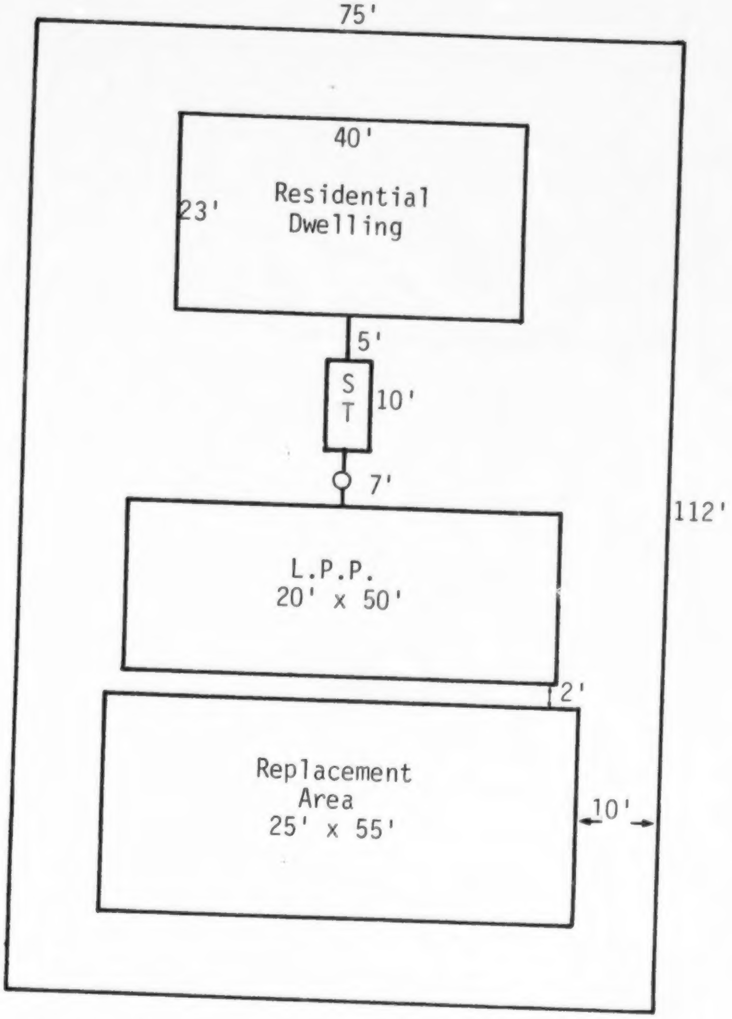
Lot Size = 10,125 sq. ft.
1 inch = 20 feet

Assumptions:

1) Served by public water system
2) Lot platted after January 1983
3) Building setback requirements do not exist
4) Wells, canals, marshes, etc. on adjoining land must meet isolation distance requirements
5) Proposed and future repair absorption area rated suitable

Figure E-3. Single family residence conventional septic tank sewage system--trench configuration

Source: Gannett Fleming Corddry and Carpenter, Inc. 1982

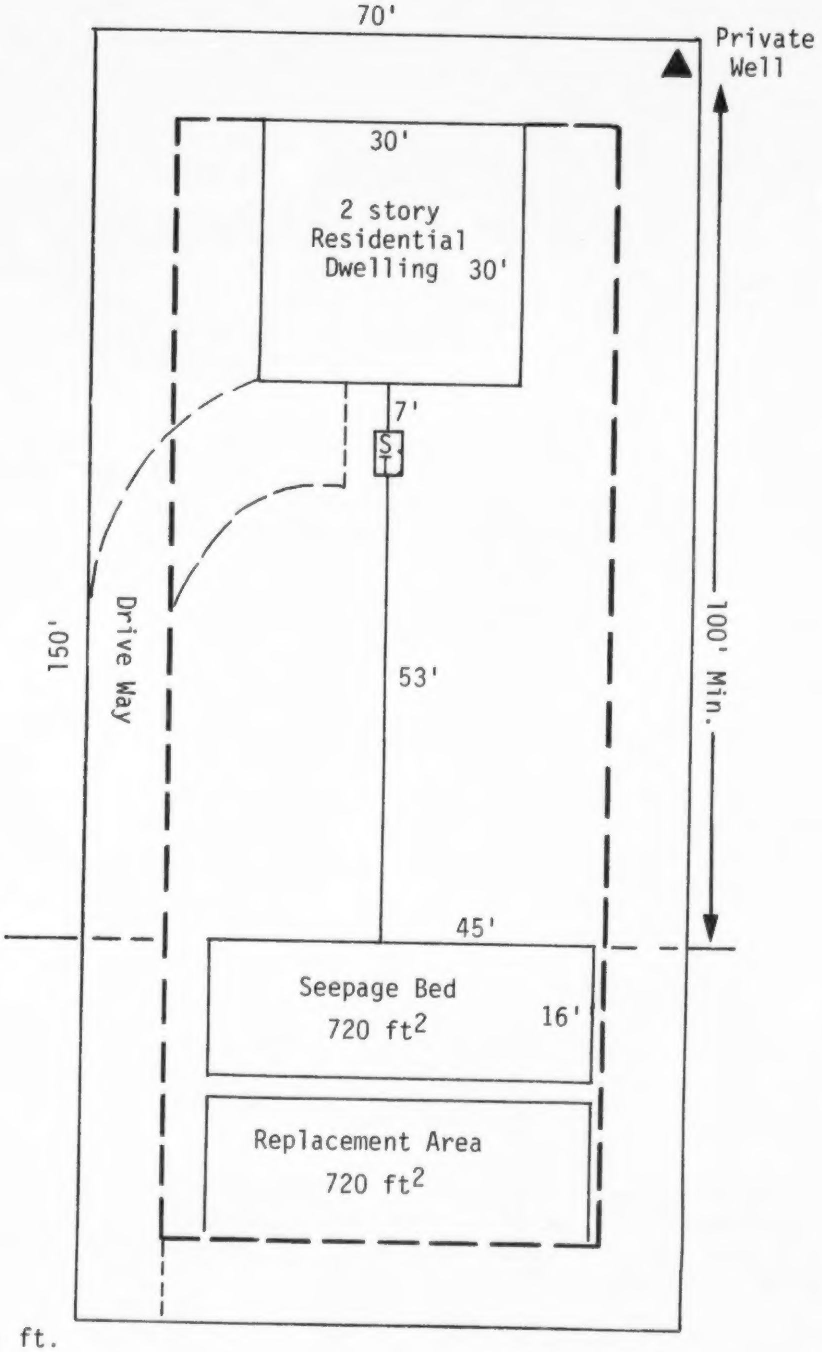

75'
40'
23'
Residential Dwelling
5'
S T
10'
7'
112'
L.P.P.
20' x 50'
2'
Replacement Area
25' x 55'
10'

Lot Size = 8,400 sq. ft.
1 inch = 20 feet

Assumptions: Same as preceding example, Figure E-3.

Figure E-4. Single family residence conventional septic tank sewage system--low pressure pipe configuration

Source: Gannett Fleming Corddry and Carpenter, Inc. 1982


70'
Private Well
30'
2 story Residential Dwelling
30'
7'
ST
53'
Drive Way
150'
100' Min.
45'
Seepage Bed
720 ft2
16'
Replacement Area
720 ft2

Lot Size = 10,500 sq. ft.
1 inch = 20 feet

Note: Well is located greater than 100' from any other septic tank soil absorption system.

Figure E-5. Single family residence on 10,500 ft^2 lot platted prior to January 1983 with private well

Source: Gannett Fleming Corddry and Carpenter, Inc. 1982

Figure E-6 shows a row of attached townhouses with a seepage bed for the primary disposal area and a trench area for the replacement area should the bed area fail.

Mid-rise Apartments

This type development was approached from the standpoint of what is the maximum design flow that can be accommodated on one acre of land. The design loading appears to be approximately 5400 gpd which would result from flows from 45 bedrooms. Nearly 50 percent of the tract would be required for a primary area seepage bed and a trench system replacement area. Approximately 900 ft^2 would be required for locating the five septic tanks and pumping chamber.

Architecturally, the development could take the form of a five-story apartment building with a mixture of one, two and three bedrooms and parking underneath. No amenities package is provided. Figure E-7 is based on the availability of a public water supply and does not account for more stringent setback requirements which may be required by local zoning ordinances.

Soils are sands or loamy sands. Unless very high total dissolved solids were encountered, mounding should not be a problem in these soils. In less permeable soils, such problems might occur.

The following design criteria apply to this example:

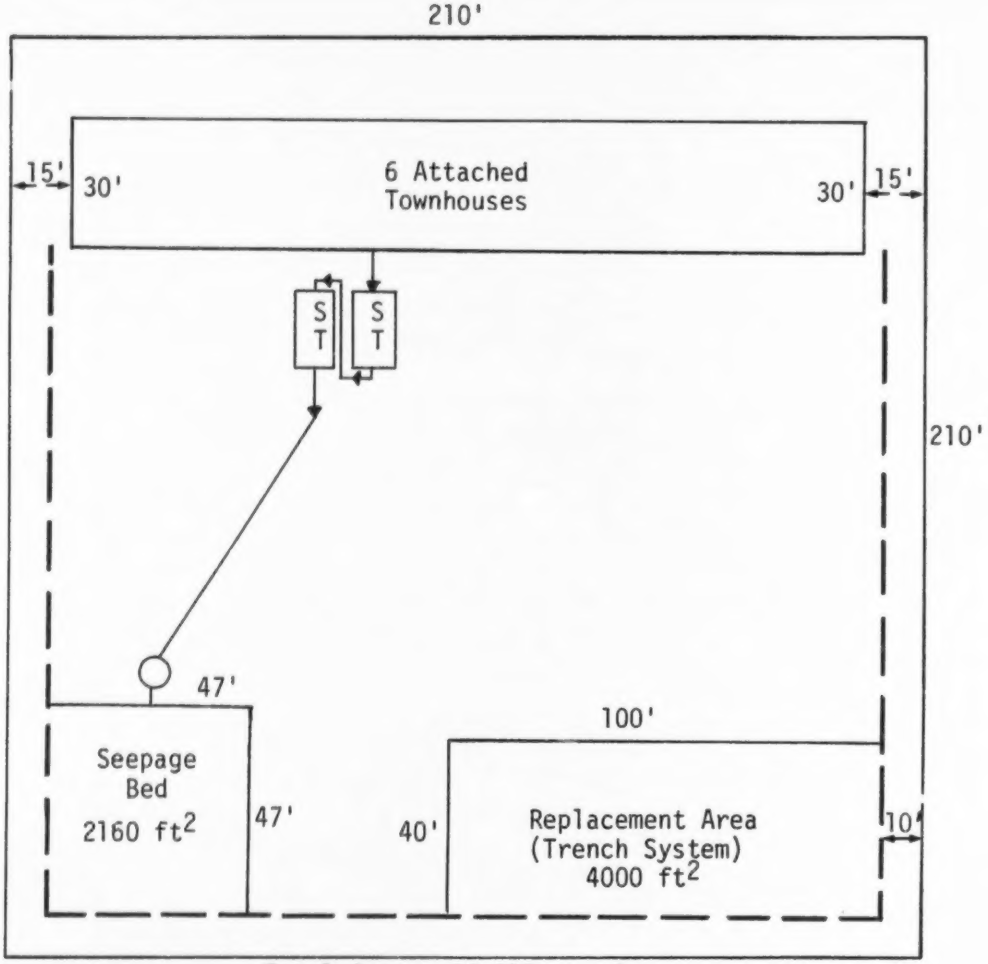
Sewage flows: 120 gpd from 45 bedrooms resulting in a total flow of 5400 gpd
Wastewater application rate: 1.0 gpd/ft^2 for sands
Required nitrification area:
Trenches: 5400 gpd - 1.0 gpd/ft^2 = 5400 ft^2 of bottom area
Assume 1800 linear ft of 3 ft wide trenches on 9 ft centers giving a total trench area of 15,300 ft^2

Bed: 5400 ft^2 x 1.5 = 8100 ft^2 bed area

It could be argued that a project containing 18-20 units per acre and no amenities package is not marketable in a resort area. The point, however, is to demonstrate that design flows of 5400 gpd are physically possible under North Carolina regulations.

Figure E-8 shows an alternative method of handling the same design flows used in Figure E-7. In this case, a rotary distributor system is utilized and a significantly larger land area is required due to the need for isolation distances and buffers.

The following design criteria apply to this example:
Sewage flows: 5400 gpd
Wastewater application rate: 1.0 gpd/ft^2 for sands
Treatment facility: multiple septic tanks in series, capacity 6800 gal.; sand filter, 2500 sq. ft. surface area; disinfection.
Application area: moderately drained soils, approximately 2.7 ac.

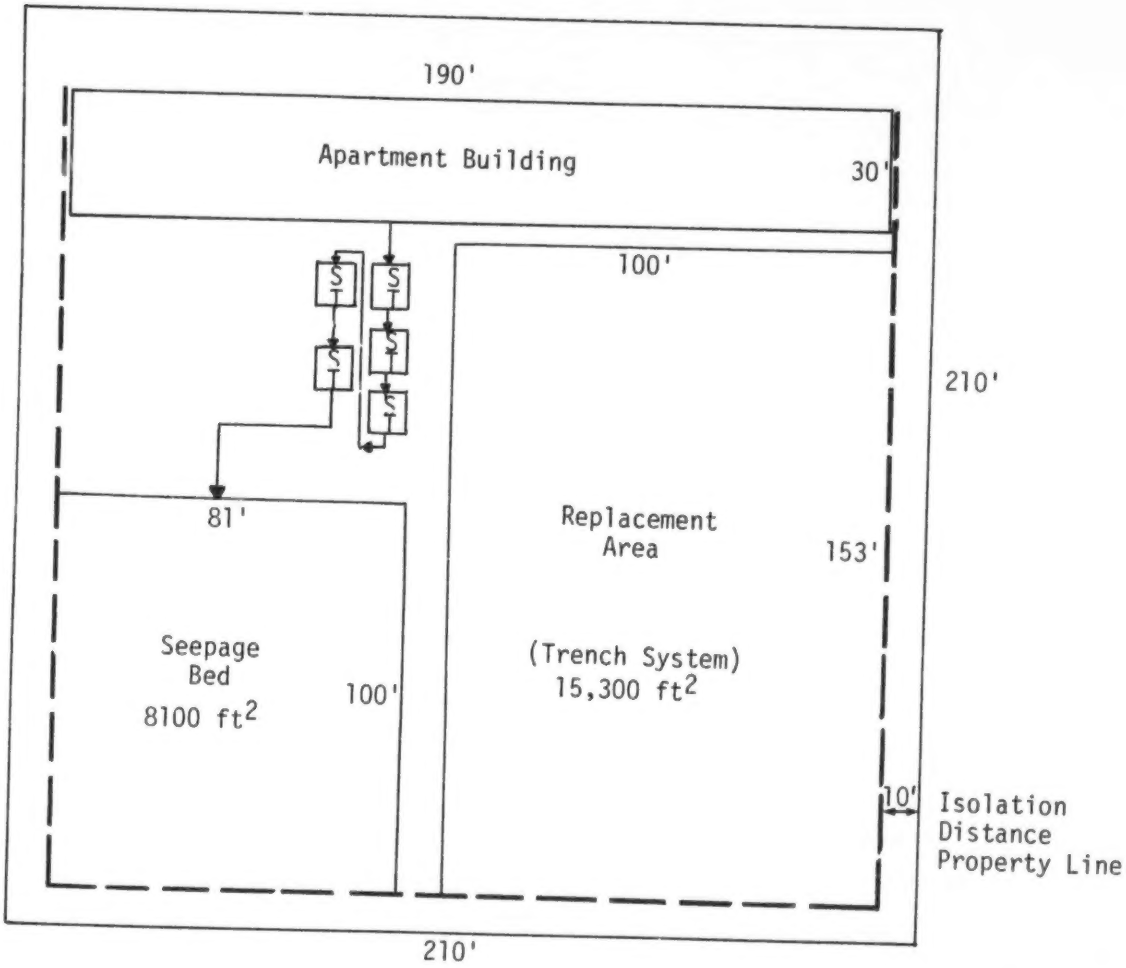

210'
15'
30'
6 Attached Townhouses
30'
15'
S T
S T
210'
47'
Seepage Bed
2160 ft²
47'
100'
40'
Replacement Area (Trench System) 4000 ft²
10'

Total Area = 44,100 sq. ft.
1 inch = 40 feet

Note: 1) Beds can only be used when site conditions prohibit the use of trenches. Their use must be approved by the local health department.
2) Adequate suitable space must be available for construction of a trench system in the replacement/repair area.

Figure E-6. Six attached townhouses

Source: Gannett Fleming Corddry and Carpenter, Inc. 1982

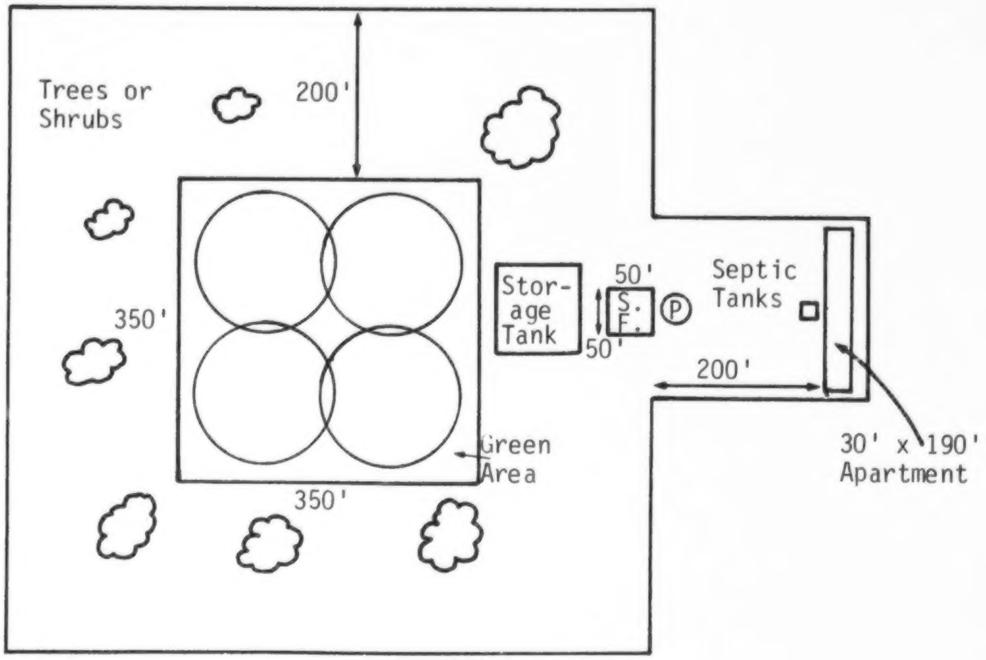

190'
Apartment Building
30'
S
T
100'
210'
81'
Replacement
Area
153'
Seepage
Bed
8100 ft²
100'
(Trench System)
15,300 ft²
10'
Isolation
Distance
Property Line
210'

Total Area = 44,100 sq. ft.
1 inch = 40 feet

Note: 1) Use of beds may be authorized by the local health department when site conditions prohibit the use of trenches.
2) Adequate suitable area must exist for a trench-type repair/replacement system.

Figure E-7. Mid-rise apartment

Source: Gannett Fleming Corddry and Carpenter, Inc. 1982


Trees or Shrubs
200'
350'
Storage Tank
50'
S.F.
P
50'
Septic Tanks
200'
Green Area
350'
30' x 190' Apartment

Total Area = 615,000 sq. ft.
1 inch = 200 feet

P = Pump
S.F. = Sand Filter

Assumptions:

Treatment facility is greater than or equal to:
500' from an impounded public water source
100' from a well
100' from surface waters classified SA

Figure E-8. Rotary Distribution System for Wastewater Disposal

Source: Gannett Fleming Corddry and Carpenter, Inc. 1982